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Characterization of Population and Usage of Unvented Kerosene Space Heaters

Applied Management Sciences, Inc., Oak Ridge, TN

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16. ABSTRACT The report gives results of a study of the market penetration of unvented kerosene space heaters (UKSHs) in the residential sector. The study was aimed at gathering baseline information to help assess the magnitude and potential severity of a problem involving emissions from unvented appliances, one of a number of synergistic factors affecting indoor air quality. UKSHs can be a significant source of such emissions. UKSH usage patterns were also investigated. Annual sales of UKSHs are estimated at 825,000 units. Leading brands include convective units marketed by Toyotomi USA (Kero-Sun) and Corona USA. Some units contain built-in catalytic filters for odor control. Add-on catalytic filters are available from at least one manufacturer. It is believed that 15-17 million portable UKSHs have been sold in the U.S. since the early 1970s. However, it is estimated that, in the 1986-87 heating season, there were only about 7 million units in use. About half of these units are in the South. Depending on whether UKSHs are used as primary or secondary heating sources, they may be used anywhere from 2 to 17 hours a day. Eighty percent of UKSHs are used in multi-family dwellings and mobile homes. While the number of UKSHs is fairly evenly distributed across income classes, most kerosene consumption is by lower income groups.

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Kerosene	Stationary Sources	21D
Combustion	Indoor Air Quality	21B
Space Heaters	Market Penetration	13A
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CHARACTERIZATION OF POPULATION AND USAGE OF UNVENTED KEROSENE SPACE HEATERS

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ABSTRACT

Indoor air quality is affected by a number of synergistic factors, including combustion emissions from unvented appliances. Unvented kerosene space heaters (UKSH) can be a significant source of such emissions. To gather baseline information to help assess the magnitude and potential severity of this problem, this study investigated the market penetration of UKSH in the residential sector. UKSH usage patterns were also investigated.

Unvented kerosene space heater technology is fast evolving, and a common technical nomenclature is difficult to define. Many individual manufacturers employ their own terminology. Most units are characterized by heat transfer mechanism (convective or radiant), flame type (blue or white), and combustion mechanism (single or dual stage combustion and wick-fed or wickless). There are many variations and combinations.

Annual sales of unvented kerosene space heaters are estimated at 825,000 units. Leading brands include convective units marketed by Toyotomi USA (Kero-Sun) and Corona USA. Some units contain built-in catalytic filters for odor control. Add-on catalytic filters are available from at least one manufacturer.

It is believed that 15-17 million portable kerosene space heaters have been sold in the United States since the early 1970's. However, it is estimated that in the 1986-1987 heating season, there were only approximately 7 million units in use. About half of these units are in the South. Depending on whether unvented kerosene space heaters are used as primary or secondary heating sources, they may be used anywhere from 2 to 17 hours per day. Eighty percent of UKSHs are used in multi-family dwellings and mobile homes. While the number of unvented kerosene space heaters is fairly evenly distributed across income class, most kerosene consumption is among the lower income groups (a small amount of this kerosene consumption may be used in heating equipment other than unvented kerosene space heaters).

Literature abstracts of publications relating to UKSH use and emissions are found in Appendix B to the report. Based on the predominance of UKSH use in multi-family dwellings and mobile homes, the authors recommend further study of these sectors to more specifically define usage characteristics.

This report was prepared by Applied Management Sciences Inc. under subcontract to PEI Associates, Inc. This report was submitted in fulfillment of Contract No. 68-02-4284, Task 002 by Applied Management Sciences Inc. under the sponsorship of the U.S. Environmental Protection Agency. This report covers the period from May 1988 to November 1988, and work was completed as of November 30, 1988.

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SECTION 1

INTRODUCTION

Applied Management Sciences, Inc., acting under subcontract to PEI Associates, was responsible for the technical effort under Task 002 of EPA Contract No. 68-02-4284. Task 002 involved a market research study of unvented kerosene space heaters in the residential sector of the United States. The goal of this effort was to characterize the population and usage of unvented kerosene space heaters (UKSH) to support ongoing studies of the sources of indoor air pollution. This report presents the results of this project. The project was divided into five subtasks, each is described in the following paragraphs.

The main function of Subtask 1 was to determine the five most popular brands and models of unvented kerosene space heaters sold in the United States over the 1985-86 and 1986-87 heating seasons. The results of this subtask were delivered to EPA in a letter report to allow selection of UKSHs for laboratory analysis of emissions. The findings are reported in Section 4 of this report. This subtask also included a review of industry nomenclature used to describe the different types of UKSHs. This topic is addressed in Section 3 of this report.

Subtask 2 is covered in Section 5 of this report, and involves a review of the role and prevalence of catalysts in unvented kerosene space heaters. This effort specifically focuses on the role of add-on catalytic devices.

Subtask 3, covered in Section 6 of this report, is the determination of the composition and distribution of the unvented kerosene space heaters that are currently in use in the United States. This includes the regional distributions and usage patterns of the UKSHs.

Subtask 4, addressed in Section 7, is the determination of the principal manufacturers of unvented kerosene space heaters and a projection of the future trends in the heater population composition. This analysis includes trends in sales and technology changes.

Subtask 5 involves the recommendation of a representative set of unvented kerosene space heaters for future characterization. There are two sets of heaters characterized: one representing the pre 1987-88 heating season, the other representing the estimated heater composition in the next five to ten years; these results are reported in Section 8. The other portion of this subtask presents a literature survey that addresses emissions from unvented kerosene space heaters. Appendix B contains the results of the literature search and Section 9 highlights the most relevant articles.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

This study had a research objective and an operational objective. The research objective was to describe unvented kerosene space heater technology, and to develop estimates of market penetration and usage characteristics. The operational objective was to develop recommendations for specific unvented kerosene space heaters to be laboratory tested for emissions. These recommendations were to be based on sales trends for recent/current models, and for future models.

With respect to the research objective of this study, the following conclusions can be drawn:

- In the 1986-1987 heating season, there were an estimated 7 million unvented kerosene space heaters in use in the United States.
- Depending upon whether used as a primary or secondary heating source, and geographic location, it is estimated that unvented kerosene space heaters are operated from 2 to 17 hours per day.
- Eighty percent of kerosene consumption is in multi-family dwellings and mobile homes, though not all of this consumption is in unvented kerosene space heaters.*
- Kerosene usage for space heating is generally concentrated in the lower income groups.
- Unvented kerosene space heater technology is evolving, and a common terminology or technology classification scheme does not exist.
- Some units are marketed with built-in catalytic filters for odor control, and add-on catalytic devices are available from at least one manufacturer. However, industry sources contend that future efforts will be focused on better combustion design, rather than post-combustion catalytic controls for reducing emissions.
- The literature reviewed for this study shows that unvented kerosene space heaters can be a significant source of indoor air pollutants, including certain organic compounds which may be carcinogenic.

Based on the above findings, Applied Management Sciences has identified several areas which may require further research. These areas are briefly described below.

As representative of recent/current best selling models of unvented kerosene space heaters, Applied Management Sciences recommends the Kero-Sun Omni-105, an omnidirectional convective unit marketed by Toyotomi USA, and the Corona 22DKC, an omnidirectional convective unit marketed by Corona USA. The third best-selling unit is believed to be the Robeson 03-2619-91, a

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*NOTE: Many of the estimates contained in this report are based on kerosene fuel consumption in the residential sector. It is believed that there is a high correlation between kerosene fuel consumption in the residential sector and use of UKSHs, though it is possible to burn kerosene in appliances other than UKSHs. However, it is believed that only a small fraction of residential kerosene consumption is in appliances other than UKSHs.

directional radiant unit marketed by Robeson Industries. These basic models are expected to remain big sellers over the next several years.

Representative of models which may see increased sales in the future are the Toyostove Double Clean 100 and the Toyostove Laser Clean LR450, both marketed by Toyotomi USA. The former is representative of an advanced technology for UKSHs known as dual or two-stage combustion. The latter is representative of the newer "wickless" technology.

USE OF UNVENTED KEROSENE SPACE HEATERS IN MOBILE HOMES

According to initial estimates based on consumption patterns, approximately 33 percent of unvented kerosene space heaters are used in mobile homes. Evidence indicates that mobile homes, particularly those constructed after 1974 when new standards went into effect, may be substantially "tighter" than standard single family dwellings. This is based on better quality control for factory-built housing. Lower infiltration rates in mobile homes coupled with unvented kerosene combustion could lead to substantially higher levels of indoor air pollutants in mobile homes. A complicating factor is that unvented kerosene space heaters may in many cases be the primary heating source in mobile homes (given their reduced square footage) and thus could be operated as much as 17 hours per day on average. Further, mobile homes are a fast growing segment of the housing market, and may have relatively high proportions of infants and the elderly - susceptible subpopulations. Applied Management Sciences recommends a research effort to measure infiltration rates in typical mobile homes (both pre- and post-1974) and better define the saturation and usage patterns of unvented kerosene space heaters in mobile homes. Growth rates and occupancy patterns should also be examined.

USE OF UNVENTED KEROSENE SPACE HEATERS IN MULTIFAMILY BUILDINGS

Initial estimates indicate that fully 47 percent of unvented kerosene space heaters may be used in multifamily dwellings. Most research to date on emissions has concentrated on single family dwellings, yet the standard single family dwelling sector only accounts for an estimated 20 percent of households using unvented kerosene space heaters. Further, preliminary evidence exists which indicates a wide degree of variability in infiltration rates in multifamily buildings. The major reasons are exposure and stack effects. While single family buildings typically have four exterior walls, apartments in multifamily buildings may have only one exterior wall. Limited measurements indicate that an apartment on the leeward side of a multifamily building may have infiltration rates only slightly above zero air changes per hour, though this may only be a transient situation. Use of an unvented kerosene space heater in such an apartment could periodically lead to very high levels of pollutants. Health effects are complicated by the fact that many apartment dwellers may include susceptible subpopulations such as the elderly, infants, etc. Applied Management Sciences recommends an effort to better define the saturation, usage patterns, and occupancy characteristics of UKSH usage in multifamily dwellings. This should be coupled with an emissions characterization program which includes testing in multifamily building environments.

FUEL QUALITY ISSUES

K-1 is the recommended kerosene fuel for most UKSHs. K-2 is a somewhat "dirtier" fuel which is also widely available. Since K-2 is usually slightly cheaper than K-1, some individuals may be tempted to use K-2 in their UKSH. This could lead to higher emissions rates for certain pollutants. It should be noted that this problem is not limited to willful misuse by the consumer. There have been documented cases of K-2 kerosene being labeled and sold as K-1 kerosene by

dealers. The magnitude and severity of this problem is unknown. Applied Management Sciences suggests a limited effort be undertaken to examine this issue. This would include random spot sampling of kerosene offered for sale to ascertain fuel quality coupled with characterization of the emissions of unvented kerosene space heaters when combusting K-2 kerosene.

SYNERGISTIC EFFECTS OF UNVENTED KEROSENE COMBUSTION AND COMBUSTION OF OTHER APPLIANCES

Unvented kerosene space heaters may be used in conjunction with unvented gas appliances, such as gas cooking stoves. While numerous experiments have been conducted for criteria pollutants, only limited work has been done to explicitly measure the interactive effects of gas and kerosene combustion for non-criteria pollutants (e.g. PAH's). It is suggested that a limited effort be undertaken to characterize the interactive effects. Should this result in concerns, further analysis could attempt to estimate the population of households where both unvented kerosene and gas appliances are in use.

SURVEY OF KEROSENE HOUSEHOLDS TO EXAMINE USAGE PATTERNS

In the present study, usage patterns for unvented kerosene space heaters have been estimated based on total kerosene consumption estimates. To better understand actual usage and behavior patterns, it is important to survey users to gauge variables such as number of hours of operation per day, age and health of building occupants, number of units in use, location of units, whether or not supplemental heating is used, etc. To accomplish this, a limited survey of kerosene heater users would be necessary. The suggested approach would be to "piggy back" on existing residential energy surveys such as those conducted by the U.S. Energy Information Administration, where a secondary survey would be administered to respondents having identified themselves as unvented kerosene space heater users.

SECTION 3

UNVENTED KEROSENE SPACE HEATER TECHNOLOGY DESCRIPTION AND NOMENCLATURE

This section describes the technology and terminology associated with unvented kerosene space heaters. The technology of add-on catalytic control devices is described in Section 5. Unvented kerosene space heater technology is evolving with major manufacturers introducing new technology. Consequently, the technical nomenclature is not fixed, as each manufacturer introduces new features and coins its own terminology to describe these features. Also, there is an extremely high degree of variability in heater configurations. Thus, it is difficult to be precise when describing UKSH nomenclature.

For example, a new type of technology being marketed is "multistage" combustion in which the fuel is burned more than once to achieve more complete combustion. The adaptation of this technology for UKSHs is to burn the fuel twice, hence "dual" combustion is the frequently used generic term. Individual manufacturers, however, use their own marketing terminology. For example, Toyotomi markets dual combustion units under the label "Double Clean" whereas Robeson uses the label "Kleen Burn" to describe their "dual chamber burning system."

The standard, generic (wick-fed single stage combustion) unvented kerosene space heater configuration, shown in Figure 1, is comprised primarily of a burner, wick, and fuel reservoir. The wick, which is usually made of glass fiber, draws the fuel into the burner, where combustion occurs. Cotton wicks are sometimes used in lower cost units. The unvented kerosene space heaters presently on the market vary from this standard in several capacities. These are shown in Table 1, and include heat transfer mechanism, flame type, thermal output, burner configuration, which includes combustion method and fuel feed, fuel storage, and ignition method. Table 1 should be interpreted as follows: every unvented kerosene space heater must have a device representing each bold-faced heading. That is, a UKSH must have a heat transfer mechanism, a flame type, a thermal output rating, a combustion method and fuel feed configuration, a fuel storage configuration, and an ignition method. The entries under each heading are the choices available. For example, a given UKSH can have a gravity tank or a vacuum tank for fuel storage. Any combination is usually possible - for example wick-fed, single stage combustion with a gravity tank.

The heat transfer mechanism choices are not mutually exclusive. All units have some degree of convection and some degree of radiation. The classification refers to the primary means of heat transfer. For example, if the primary means of heat transfer is by radiation, the unit will commonly be referred to as a radiant unit, though some degree of convection will still take place.

It should also be noted that the parameters indicated above are the basic combustion-related parameters. They do not include additional convenience type features such as thermostatic controls, programmable time clocks, etc.

As a broad generalization, pre-1986 unvented kerosene space heaters fall into two general categories as follows:

CATEGORY 1: Radiant blue flame, single stage combustion unit which is wick-fed, has a gravity tank, and flame (manual) or battery ignition, and a heating capacity of 10,000-15,000 BTU/hour.

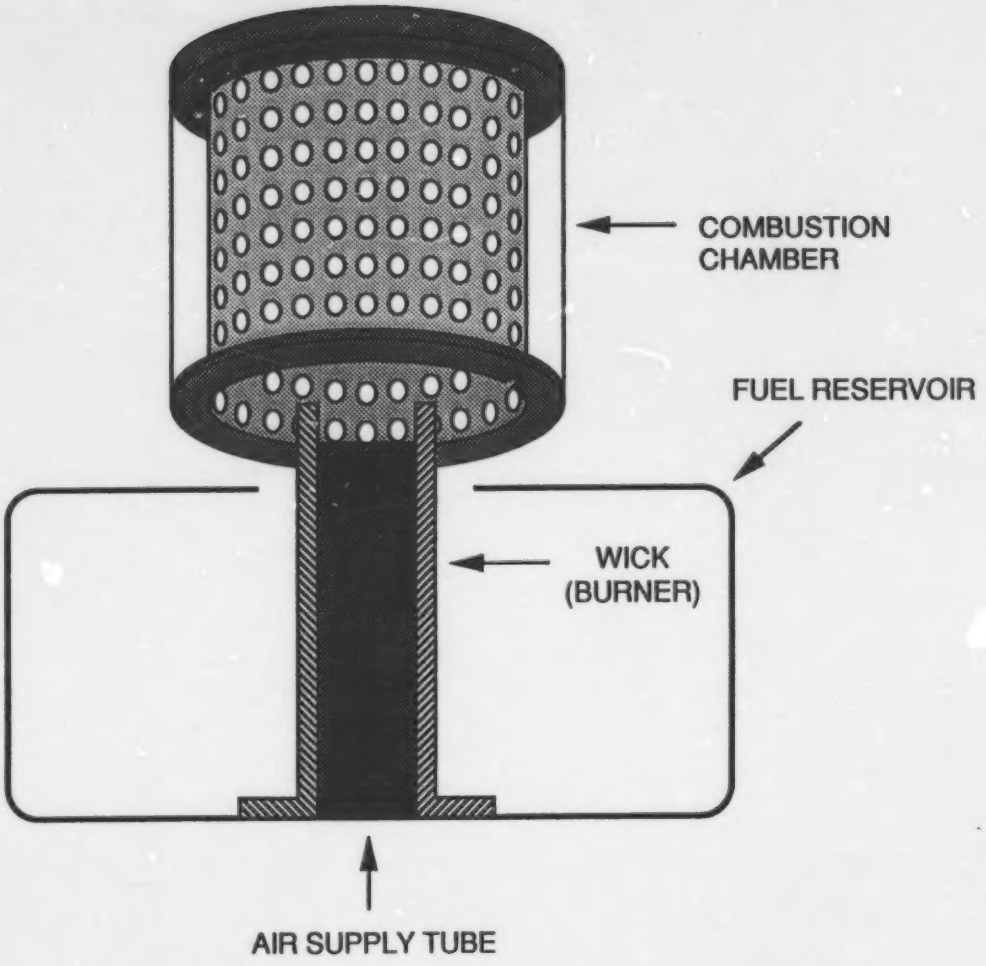

FIGURE 1: STANDARD KEROSENE COMBUSTION CONFIGURATION

SOURCE: U.L. STD 647

TABLE 1
OVERVIEW OF TYPICAL UNVENTED KEROSENE SPACE HEATER CONFIGURATIONS

PRIMARY HEAT TRANSFER MECHANISM

- OMNI-DIRECTIONAL CONVECTIVE (NATURAL)
- FORCED CONVECTION (FAN)
- DIRECTIONAL RADIANT

FLAME TYPE

- WHITE
- BLUE

THERMAL OUTPUT (Typical Unit)

- 18,000-22,000 BTU/HOUR (Convective)
- 10,000-15,000 BTU/HOUR (Radiant)

BURNER SYSTEM

COMBUSTION METHOD

- DUAL STAGE
- SINGLE STAGE

FUEL FEED

- "WICKLESS" (VAPORIZATION)
- WICK

FUEL STORAGE

- GRAVITY TANK
- VACUUM TANK*

IGNITION METHOD

- ELECTRIC (Outlet or Battery)
- FLAME (Manual)

*Usually removable.
SOURCE: APPLIED MANAGEMENT SCIENCES, INC., ANALYSIS OF PRODUCT LITERATURE

CATEGORY 2: Convective, white flame, single stage combustion unit, which is wick-fed, has a gravity tank, electric or battery ignition, and a heating capacity of 18,000-22,000 BTU/hour.

Newer models, which have been introduced in the past few years, incorporate the "wickless" feature in place of the wick, and the dual combustion burner in place of the single stage burner.

Unvented kerosene space heater models available on the market vary in the method of heat transfer to a room. These heating patterns are referred to as omnidirectional or directional. Omnidirectional UKSH casings are of a cylindrical shape which supply heat circumferentially. Directional heaters are typically geometrically square, and focus heat in one direction utilizing a metal reflector (radiant) or fan (forced convection).

The two primary methods of heat output are convective and radiant (see Figure 2). Convective heaters are typically omnidirectional and function by venting the hot air convection currents created within the casing by the burner through vents in the top of the heater. Some models use a fan (forced convection) to supply this hot air to the room. The convective units are generally in the 18,000 to 22,000 BTU/hr range of output and are characterized by a hot white flame. The radiant UKSH radiates heat from the burner directly utilizing a metal directional reflector. Radiant heaters generally fall in the 10,000 to 15,000 BTU/hr range and can be characterized by a blue flame which is cooler than the convective white flame.

While it is generally the case that omnidirectional unvented kerosene space heaters are convective and directional heaters are radiant, exceptions exist. Some UKSHs that by appearance are radiant, are actually equipped with circulation fans, thus making them convective units. Moreover, certain convective units employ the radiant method as a secondary mode of heat transfer.

Recent developments in unvented kerosene space heater technology have added further variance to the standard configuration. One product fairly new to the market eliminates the use of the wick, and is referred to as a wickless or vaporizing burner type and is marketed under two brand names: Laser Clean (Toyotomi) and Wickless (Corona). This is conceptually illustrated in Figure 3. These wickless burners achieve a high degree of efficiency by vaporizing the fuel in a chamber, using the heat of combustion or supplemental electric heat, then mixing in air to a composition ratio necessary for combustion. The output is regulated by controlling the fuel supply to the burner. A recently-developed method of combustion utilizes staged burners which burn the fuel twice, thus eliminating many byproducts of combustion. This concept is illustrated in Figure 4, and as mentioned above, is generally described as dual combustion.

There are two methods of UKSH ignition: electric and manual. Electric ignition is accomplished utilizing an electric igniter fed by batteries or a wall outlet. The second method utilizes a match or taper. Fuel is supplied to the heater either by an integral gravity tank which supplies fuel to the burner using gravity, or by a removable vacuum tank which supplies a sump (see Figure 5). The sump is a fuel reservoir from which gravity forces the supply of kerosene to the burner. The unit is turned off by terminating the flow of fuel to the combustion chamber.

As can be seen by the above discussion, technology configurations and terminology involving unvented kerosene space heaters is highly variable. Many different combinations of features are possible. This is exemplified by the fact that the leading manufacturer markets 19 different models under two brand names (see Section 4). Also, the technology continues to evolve with introduction of advanced models. Table 2 presents some common technical definitions and

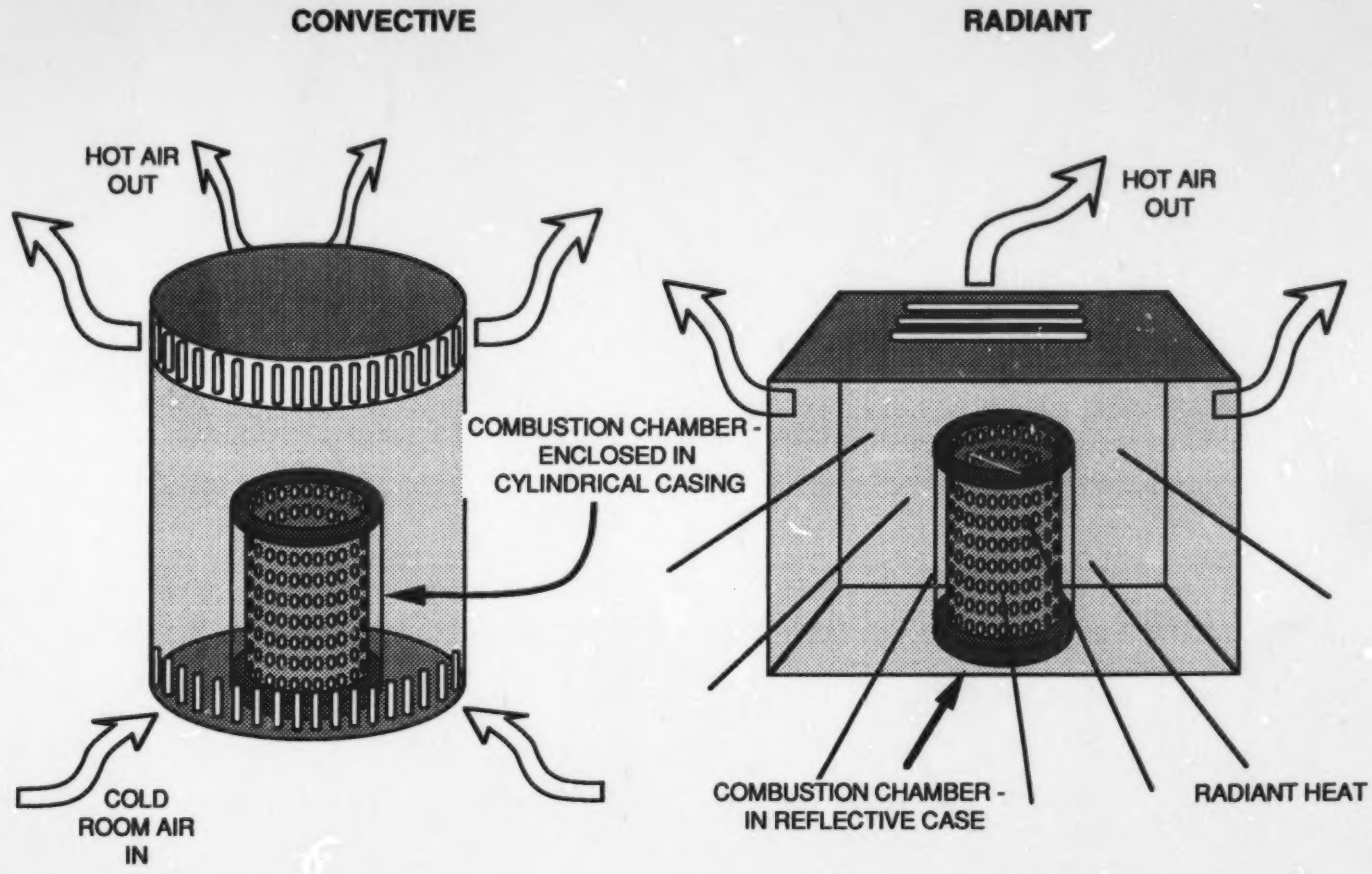

FIGURE 2: MAJOR METHODS OF HEAT TRANSFER OF UNVENTED KEROSENE HEATERS

SOURCE: APPLIED MANAGEMENT SCIENCES' INTERPRETATION OF TOYOTOMI USA, CORONA USA, AND ALADDIN INTERNATIONAL PRODUCT LITERATURE

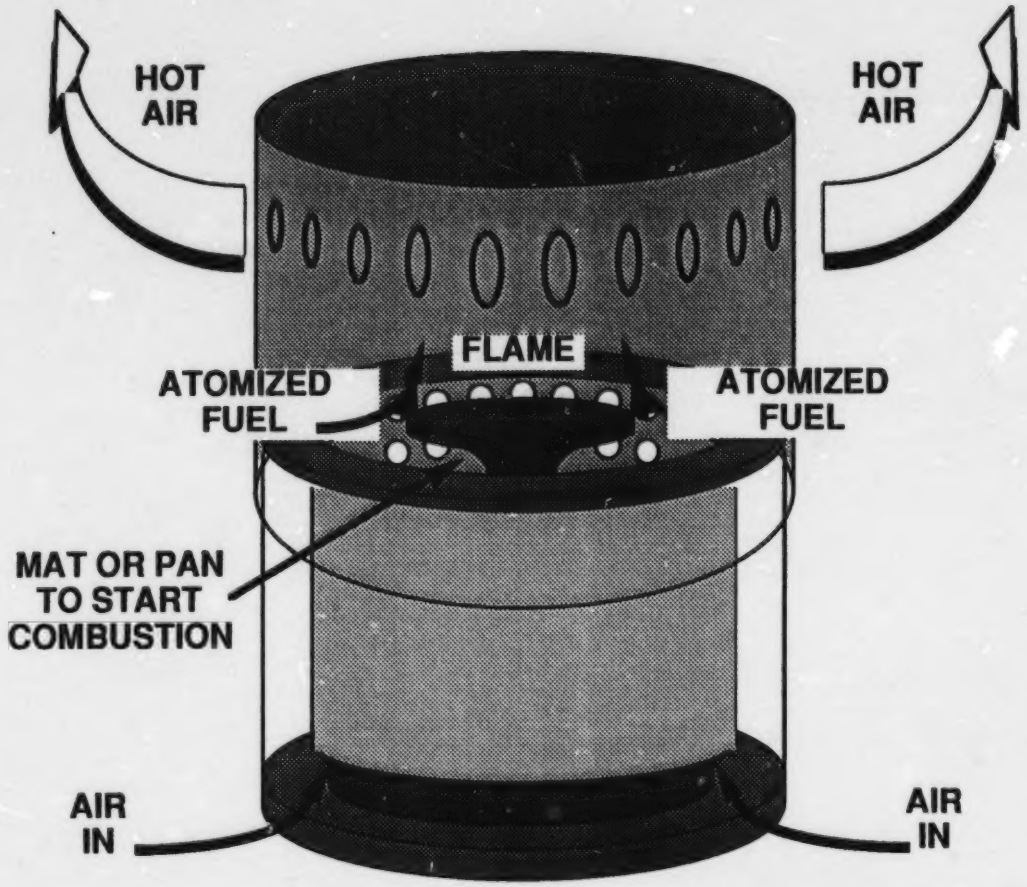

FIGURE 3: STANDARD KEROSENE HEATER WICKLESS COMBUSTION CONFIGURATION

SOURCE: U.L. STD 647

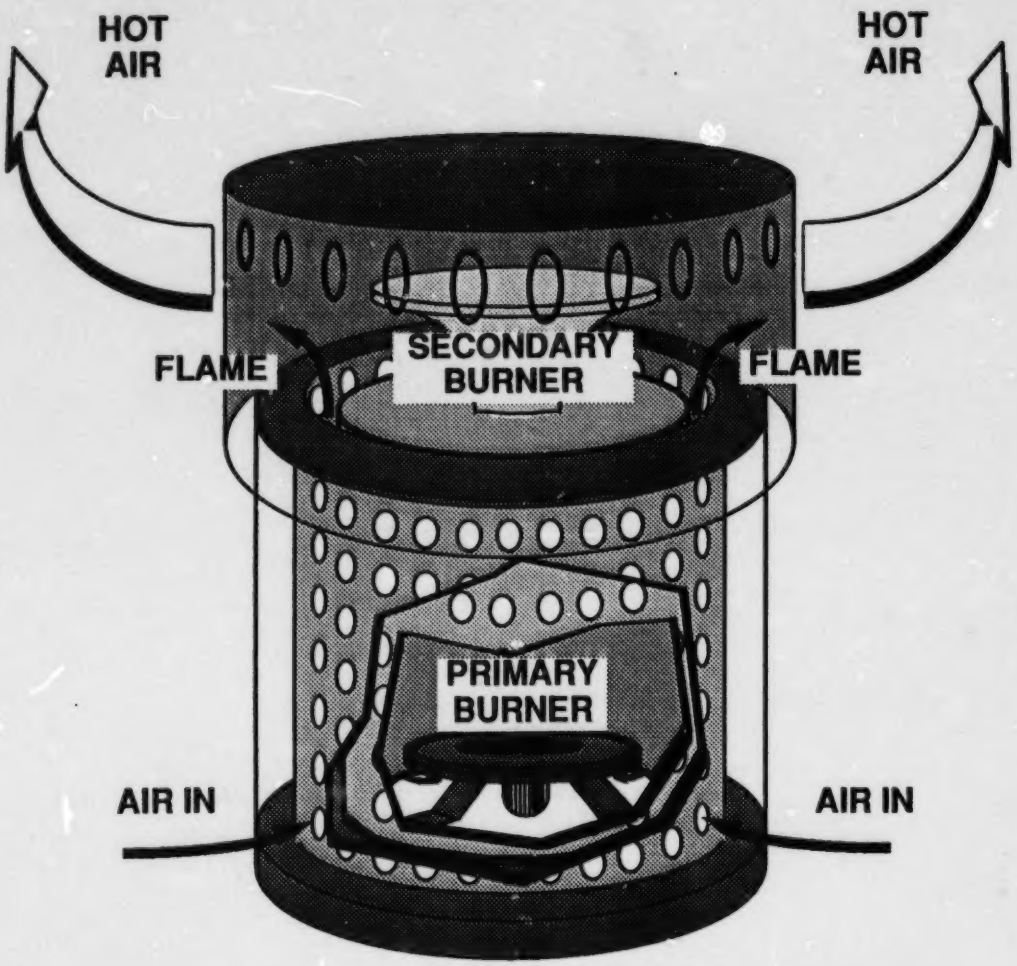

FIGURE 4: STANDARD KEROSENE HEATER DUAL COMBUSTION CONFIGURATION

SOURCE: U.L. STD 647 AND APPLIED MANAGEMENT SCIENCES' INTERPRETATION OF TOYOTOMI USA PRODUCT LITERATURE ("DOUBLE CLEAN™ MODEL)

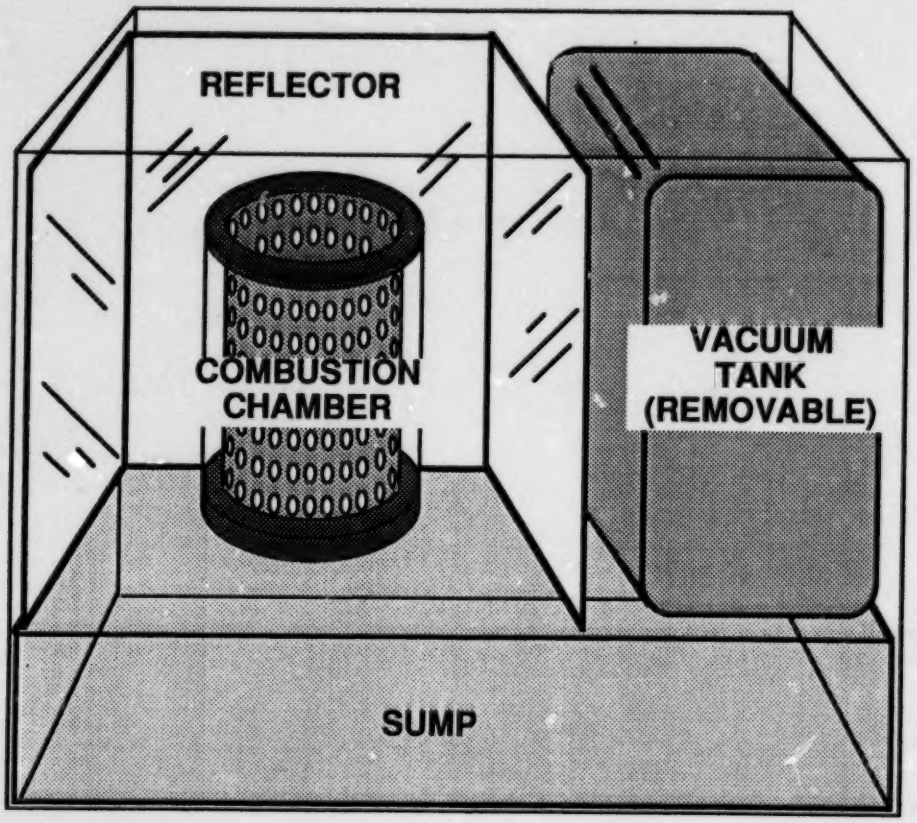

FIGURE 5: TYPICAL KEROSENE HEATER VACUUM TANK CONFIGURATION

SOURCE: KEROMATE PRODUCT BROCHURE

terminology used in the development of Underwriters Laboratories' Standard UL-647 covering unvented kerosene space heaters. It should be noted that these definitions generally pre-date the introduction of dual combustion and wickless type units.

TABLE 2

DEFINITION OF UNVENTED KEROSENE SPACE HEATER TERMS

ANTIFLOODING DEVICE - A primary safety control that causes the fuel flow to be shut off upon a rise in fuel level or upon receiving excess fuel, and that operates before the unintended discharge of fuel can occur. A wick, vacuum breaker, or other automatic device may be considered an antiflooding device.

APPLIANCE FLUE - The flue passages within the heater.

BAFFLE - An object placed in a heater to direct or to retard the flow of air or flue gases.

BASE - The main supporting frame or structure of an assembly.

BURNER - A device for the final conveyance of fuel or a mixture of fuel and air to the combustion zone.

BURNER, VAPORIZING TYPE - A burner consisting of an oil-vaporizing bowl or other receptacle to which liquid fuel may be fed in controllable quantities with provision for admitting air and mixing it with the fuel vapor in combustible proportions. The heat of combustion is used to vaporize the fuel.

BURNER, WICK TYPE - A burner consisting of a receptacle and wick to which liquid fuel may be fed in controllable quantities. The wick carries the fuel to the combustion zone where air is introduced for combustion.

CASING - An enclosure forming the outside of the heater, no parts of which are likely to be subjected to intense heat.

CATALYST - A material that speeds the oxidation of hydrocarbons and carbon monoxide into water vapor and carbon dioxide.

COMBUSTIBLE MATERIAL - As pertaining to materials adjacent to or in contact with heaters, a material made of or having surfaces of wood, compressed paper, plant fibers, or other material that will ignite and burn. Such material shall be considered as combustible even though flameproofed, fire-retardant treated, or plastered.

COMBUSTION - The rapid oxidation of fuel accompanied by the production of heat, or heat and light. Complete combustion of a fuel is possible only in the presence of an adequate oxygen supply.

COMBUSTION CHAMBER - The portion of the heater within which combustion occurs that is usually part of the heat exchanger.

CONSTANT-LEVEL VALVE - A device for maintaining within a reservoir a constant level of fuel for delivery to the burner.

MANUALLY LIGHTED HEATER - A heater in which fuel to the main burner is turned on only by hand and ignited under supervision.

PORTABLE HEATER - A direct-fired heater that:

A. Is intended to burn kerosene,
B. Is not flue connected,

C. Can be carried from one location to another,
D. Is self-supporting and self-contained, and
E. Includes either an integral or a removable fuel tank.

RADIATION SHIELD - A separate panel or panels interposed between heating surfaces and adjacent objects to reduce heat transmission by radiation.

READILY ACCESSIBLE - Capable of being reached easily and quickly for operation, adjustment, and inspection.

SUMP (FOUNT) - The receptacle employed with a vacuum tank.

TANK, GRAVITY - A fuel tank from which the fuel is delivered directly to the burner by gravity.

TANK, INTEGRAL - A fuel tank that is permanently attached to a heater.

TANK, REMOVABLE - A fuel tank that can be separated from a heater, without the use of a tool, for filling.

TANK, VACUUM - A fuel tank that maintains a definite level of fuel in a sump or similar receptacle by barometric feed. Fuel is delivered from the sump to the burner by gravity.

TRACER FLAME - Small flickers or a trickle of flame at or above the wick of a wick-type burner that may continue to burn due to presence of kerosene vapors after the main burner flame has been extinguished.

VALVE, FUEL-CONTROL - An automatically or manually operated device consisting essentially of a fuel valve for controlling the fuel supply to a burner.

A. Metering (Regulating) Valve - A fuel-control valve for regulating burner input.
B. Safety Valve - A normally closed valve of the On and Off type (without any bypass to the burner) that is actuated by a primary safety control or by an emergency device.

VALVE, MANUAL FUEL-SHUTOFF - A manually operated valve in the fuel line for the purpose of completely turning on or shutting off the fuel supply to the burner.

SOURCE: UL-647

SECTION 4

MARKET SHARE AND SALES OF MAJOR UNVENTED KEROSENE SPACE HEATER BRANDS

Applied Management Sciences conducted a review of available literature and sources on the unvented kerosene space heater market. In addition to review of literature and standard market information sources (e.g., Dun and Bradstreet), Applied Management Sciences conducted telephone interviews with UKSH market experts and knowledgeable industry sources.

Because little data exist on sales by brand of unvented kerosene space heaters in the United States, Applied Management Sciences had to derive these estimates from the information accessible from various industry sources. These sources are synopsized in the References/Sources section of this report. The following paragraphs summarize the approach used to extrapolate from available sources and reports the resulting estimates for the five most popular unvented kerosene space heater models sold in the United States.

Estimates of the total sales volume of unvented kerosene space heaters in the U.S. over the past three years were obtained from three sources (See Table 3). While the Kerosene Heater Manufacturers Association could report no hard data, they estimated that total UKSH sales have been flat since the 1983-84 time frame, a fact further corroborated by the other sources contacted. At the time they were contacted (May 1988), the Kerosene Heater Manufacturers Association estimated current U.S. annual sales of UKSHs at about 1 million units. Mr. Gordon Potter, a consultant to the kerosene heater industry, postulates annual sales at between 650,000 and 800,000 units, but believes them to be substantially below one million units. The Consumer Product Safety Commission (CPSC) approximates annual sales at 750,000 units, however, their estimate was derived from information also provided by the Kerosene Heater Manufacturers Association, though at an earlier time. Taking the midpoint of the Potter estimate (750,000 units) and then averaging all three estimates, Applied Management Sciences derived an overall sales estimate of 825,000 units

TABLE 3: ESTIMATES OF TOTAL ANNUAL SALES OF UNVENTED KEROSENE SPACE HEATERS (1985-1986 AND 1986-1987)

SOURCE	ESTIMATED ANNUAL SALES (Number of Units)
Kerosene Heater Manufacturers Association (H. Smith)	1,000,000
Gordon Potter, Industry Consultant	650,000-800,000
CPSC (From Kerosene Heater Manufacturers Association)	750,000
Applied Management Sciences derived estimate*	825,000

* Derived by using midpoint of Potter estimate and taking average of the three estimates.

for each of the 1985-86 and 1986-87 heating seasons. This volume is significantly lower than sales in the late 1970's, when annual sales were estimated at around 2-3 million units.

Further investigation revealed that for heavily used unvented kerosene space heaters, lower cost units may have a lifetime as little as 3-4 years and higher cost units may have lifetimes of 10-30 years. Lifetime is primarily a function of general user care and maintenance, periodic wick replacement, and use of the proper grade K-1 fuel. Given these lifetimes, it is postulated that a significant portion of the [illegible]000 units sold each year are replacement units for heaters which have reached the end of their useful lives after heavy usage. Many of these units may have been purchased in the mid to late 1970's. Data do no exist to estimate precisely the proportion of replacement sales versus first-time buyer sales.

Next, Applied Management Sciences determined the leading manufacturers of unvented kerosene space heaters sold in the United States. According to industry sources, almost all unvented kerosene space heaters sold in the United States are manufactured in Japan and imported into the U.S. market. While several brands are actually manufactured in the U.S., the manufacturers utilize Japanese technology under license. Table 4 ranks the five leading manufacturers/distributors

TABLE 4: MARKET SHARE OF THE TOP FIVE MANUFACTURERS OF UNVENTED KEROSENE SPACE HEATERS

Est. Rank	Manufacturer/ Distribution	Market Share (%)	Est. # Models Produced	Est. Share, Total Firm's Sales of Leading Model (%) ***
1	Toyotomi USA	40*	19	
	a. Kero-sun		7	28.6***
	b. Toyostove		12	13.3***
2	Corona USA	20	6	33.3***
3	Robeson Indus.	12	3	49.5****
4	RMC, Int'l	8	3	49.5****
5	Aladdin Int'l	5	3	49.5****
-	All Others	15**	--	
		100		

* Source: Advertising Age Magazine; December 17, 1984; page 41, and Kerosene Heater Manufacturers Association

** According to the Kerosene Heater Manufacturers Association, the top five manufacturers account for approximately 85 percent of total annual sales.

*** Based on doubling the average model share.

**** Based on multiplying average share by 1.5.

of unvented kerosene space heaters in the U.S. market. The five leading manufacturers/distributors as reported by industry sources are Toyotomi, Corona, Robeson Frigid, RMC International, and Aladdin. These five firms are estimated to account for 85 percent of the total U.S. unvented kerosene space heater sales according to the Kerosene Heater Manufacturers Association. Toyotomi is considered to be the industry leader by a substantial margin. Based on this information, Applied Management Sciences estimated the market shares for each of the top five manufacturers shown in Table 4.

A complicating factor is that each manufacturer markets a variety of brand names and models. For example, Toyotomi U.S.A. markets three separate brands of UKSHs: Kero-sun, Toyostove, and Toyoset. Each brand, in turn, also has several models. In total, Toyotomi U.S.A. markets 19 different models of UKSHs in the United States. The number of models marketed by the other leading manufacturers are shown in Table 4.

Given this information, Applied Management Sciences developed sales estimates for the leading model marketed by each of the top five manufacturers. This market share was broken down into two categories. Those manufacturers with more than five models of heaters within a given brand name, and those with less than five. For those marketing more than five models it was assumed that the leading model carries twice the sales of the average model, and for those with less than five a factor of one and a half times the average model. The basis for this assumption is taken from the calculations of manufacturers with three models, who indicate that the leading model did not account for 66% of their total sales due to there being a second model which also "sells well." Applied Management Sciences believes a 45-50% share would be more reasonable in this case.

As an illustration of this methodology, Toyotomi provides a useful example. If each of Toyotomi's 19 heater models sold equal units each year, then each would account for 1/19 (5.3%) of the total sales. However, of the 19 models, seven are sold under the Kero-Sun brand name and 12 are sold under the Toyostove name. Even though there are fewer Kero-Sun models, the manufacturer reported a higher Kero-Sun sales volume. This report enabled Applied Management Sciences to assume a 60-40 percent market split between the Kero-Sun and Toyostove brands. As shown in Table 4, Toyotomi's estimated market share of 40 percent (of 825,000 units) is 330,000 units. The 60/40 split between brands means Kero-Sun accounts for 198,000 units and Toyostove 132,000. Taking 1/7 (14.3 percent) and doubling it, leads to a 28.6 percent share of 198,000 units of Toyotomi's leading model sold. This volume is equal to 56,571 Omni 105 heaters sold per year as indicated in Table 5 (the Omni 105 is the Kero-Sun brand's best selling model). Since the best selling model of the Toyostove brand is unknown, the average percent was used and resulted in an estimation of only 11,000 of these units sold, which excludes this brand from further study.

This same logic is applied to the leading models of the other four top manufacturers and the results are reported in Table 5.

Estimates for 1985-86 and 1986-87 are the same based on the industry's assertion that sales have been flat for the last several years. Also reported in Table 5 is the general heater type for each of these models. As can be seen, three of the five top selling models are omnidirectional convective type heaters.

One basic caveat underlies the results of Table 5. As the title indicates, Table 5 reports the estimated sales of the leading models of each of the top manufacturers. This may or may not be the same as the top five models irrespective of manufacturer. For example, it is possible that Toyotomi's number two model could have greater sales than Corona's number one model. However, there are no data available to analyze this, as the manufacturers are unwilling to report detailed

information on sales of their different brands and models. Applied Management Sciences believes that the differential in terms of unit sales for each model would be relatively minor. Further, it may be in EPA's best interest to test heaters from different leading manufacturers.

TABLE 5: ESTIMATED LEADING MODELS AND ANNUAL SALES OF TOP FIVE UNVENTED KEROSENE HEATER MANUFACTURERS

Manufacturer/ Distributor	Brand Name	Model	Type	Est. Units Sold in U.S. 1985-1986*
Toyotomi	Kero-sun	Omni-105	Omnidirectional Convective	56,571
Corona USA	Corona	22DKC	Omnidirectional Convective	54,945
Robeson Indust.	Robeson	3-2619-91	Directional Radiant	49,005
RMC, Int'l.	Keroheat	CV2200	Omnidirectional Convective	32,670
Aladdin Int'l.	Aladdin	TR3000	Directional Radiant	20,419

* Applied Management Sciences believes approximately the same sales volume applied to the 1986-1987 heating season based on industry reports of flat sales.

Not indicated in the above analysis are some of the newest UKSH models which, according to industry sources, have been popular over the last one to two years. New technologies, such as dual combustion (Double Clean by Toyotomi) and wickless heaters, may exceed the sales of the most popular models sold in 1985-86 and 1986-87. Therefore, while EPA may wish to choose heaters from Table 5 for characterization, these should be taken to represent 1986-87 and prior sales years. Heater types which may be more indicative of sales over the next five to ten years might include the newer dual combustion and wickless models (for example, the Kero-Sun Double Clean 90 and Toyostove LR450 Laser Clean). The reader is referred to Sections 8 and 9 for a discussion of manufacturing trends and heater types for future characterization.

SECTION 5

ROLE AND PREVALENCE OF ADD-ON CATALYTIC CONTROL DEVICES

TECHNOLOGY DESCRIPTION

Catalytic control devices take the form of a platinum-coated filter which is non-toxic and can withstand the high temperatures of the burner. The filter can be of the screen, honeycomb or sponge type, the latter having a ceramic coating to withstand the heat. These general types are illustrated in Figure 6. The filter is easily-removable and is positioned so that the burner flames do not impinge on the catalyst (as mandated by U.L. Standard 647). As shown in Figure 6, the filter is situated between the burner and the path of the combustion exhaust, allowing the exhaust to pass through the filter. The hydrocarbon and carbon monoxide emissions are oxidized by the catalytic material, forming carbon dioxide and water vapor. The reaction requires oxygen unused in the original combustion, and at least 300 degrees Fahrenheit for the reaction to occur.

MAJOR MANUFACTURERS AND SALES ESTIMATES

Catalytic devices are available as standard equipment on some unvented kerosene space heaters or can be purchased as an add-on filter that will fit most models. Recent improvements in the efficiency of combustion have rendered such devices less common.

According to industry sources, few if any major heater models currently marketed in the United States include catalysts as standard equipment. Several years ago one or two models were manufactured with built-in catalysts; however, these models have been discontinued. The newer, vaporization burner (or wickless) type, have a form of integral catalytic control device. The Laser Clean by Toyotomi uses a catalytic material above the chimney to reduce emissions, and similarly, the Corona wickless model utilizes a "Catalytic Deodorizer." However, these devices will not make a difference in testing since the U.L. Standard 647 states that the catalytic device must be removed for the combustion/emission test. Employing the approach described in Section 4, Applied Management Sciences estimates that 1987-88 sales of the Laser Clean model are in the neighborhood of 10,000 units per year, and sales of the Corona wickless version are approximately 22,000 units per year (both models contain built-in catalysts).

Add-on catalytic devices are available from certain dealers for use with existing heaters. Sales of these add-on catalytic devices reached their peak in popularity in the late 1970's, when high energy prices peaked the demand for unvented kerosene space heaters. At the time, unvented kerosene space heaters were largely unregulated. There were no Federal regulations, although several states and some local authorities regulated (or banned) unvented kerosene heaters, mostly on the basis of fire hazard. Lack of regulation, coupled with high consumer demand, encouraged many marginal manufacturers to market inferior units. These marginal units had poor combustion properties which produced offensive odors. These odors prompted after-market manufacturers to appear with catalytic filters designed to reduce the odor. In 1982, the U.L. standard concerning unvented kerosene space heaters was promulgated. The standard tended to eliminate the inferior models on the market and reduced the demand for the add-on catalytic filters to a point where there is currently only one major manufacturer that could be identified.

Industry sources contacted do not foresee a major role for catalysts either in future UKSH manufacturing or as add-on devices. Rather, the industry has concentrated on advanced combustion technology and advanced burner design to achieve the most complete combustion

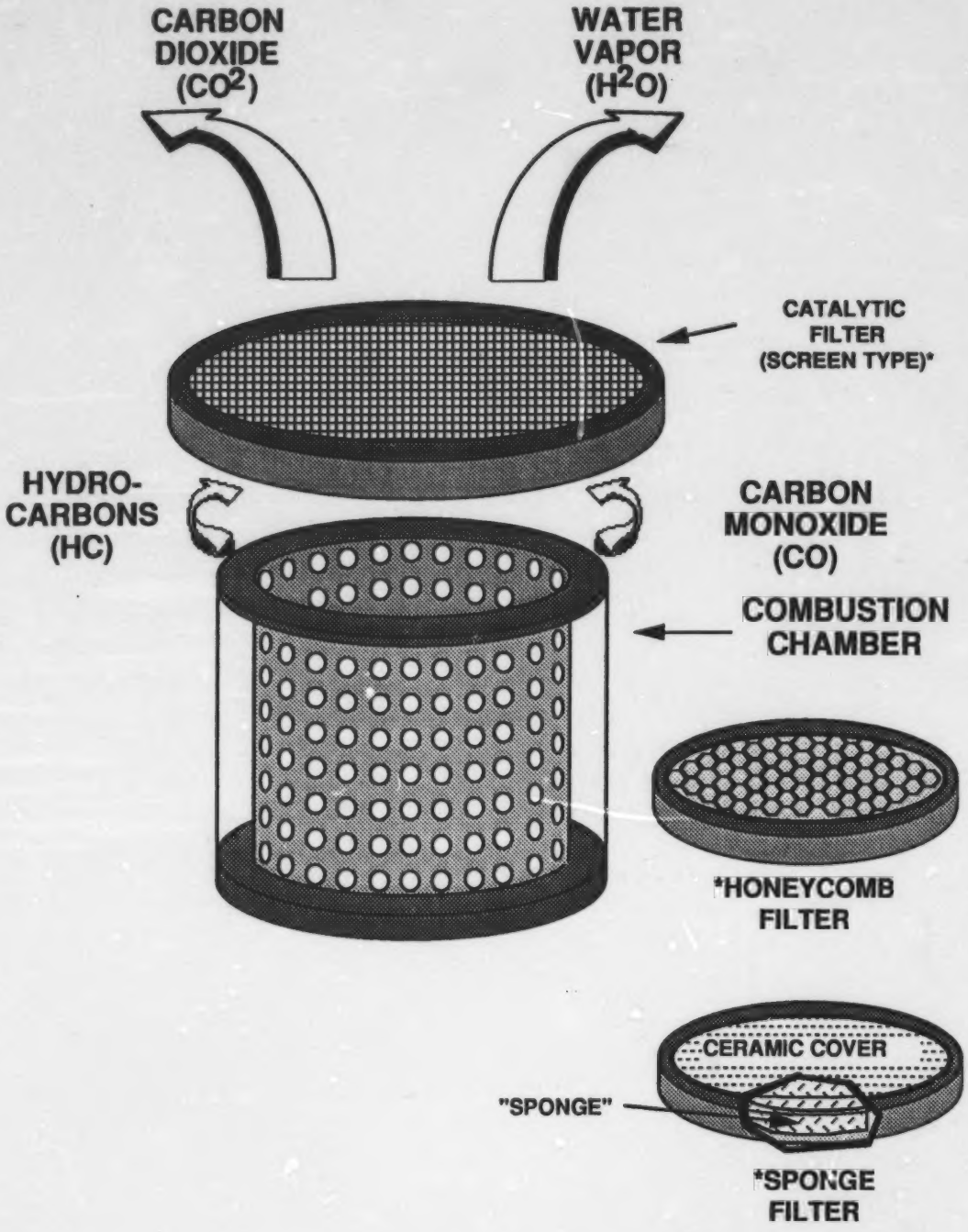

FIGURE 6: TYPICAL CATALYTIC FILTER OPERATION

SOURCE: KEROMATE PRODUCT BROCHURE AND APPLIED MANAGEMENT SCIENCES

possible. A primary example is the dual combustion type of heater. The second combustion stage essentially replaces the role of a catalytic reaction. Industry sources believe catalysts can be useful, but they also point out that recent model heaters have achieved such efficient combustion levels that the results of using a catalyst are almost imperceptible.

Primary add-on sales cater to consumers concerned with odorous emissions. However, heater servicing or adjustments generally can eliminate odors. Furthermore, odor emission at start-up or shut-down is normal since the combustion reaction is incomplete at those times. Industry sources hypothesize that add-on catalysts may continue to be used with older heaters. Panasonic, once a major manufacturer of add-on catalysts, halted production in 1986. Another major manufacturer, Keromate, discontinued its "catalytic converter" in 1987. The Keromate unit was comprised of a screen coated with platinum, and was expected to last about three years.

The only apparent current manufacturer of add-on catalytic devices for unvented kerosene space heaters is Met Pro Corporation of Harleysville, Pennsylvania. Met Pro referred to themselves as the only remaining significant manufacturer of add-on catalytic devices for unvented kerosene space heaters. Their single model, the "Breathe Easy," is a platinum-lined filter which fits nearly all heater sizes except the very small ones. Met Pro estimates sales at 300,000 units over the past six years sold at the steady rate of approximately 50,000 units per year. These units can last up to four years with proper heater maintenance and use of the recommended fuel (K-1 kerosene), and by not allowing the flame to impinge upon the filter. However, according to Met Pro, many people replace their catalysts yearly.

SECTION 6

UNVENTED KEROSENE SPACE HEATER GEOGRAPHIC DISTRIBUTION AND USAGE PATTERNS

GEOGRAPHIC DISTRIBUTION

Figure 7 shows the approximate unvented kerosene space heater population in use by U.S. census region. While estimates indicate that 15-17 million units have been sold since the early 1970's, it must be noted that only a portion of these units are believed to still be in use. This is largely due to the decline in price of conventional heating fuels, primarily oil and gas, during the mid 1980's. With lower conventional energy prices, and the effort involved in fueling and using unvented kerosene space heaters, it is believed that many of these units have been put in storage or discarded.

The primary concentration of unvented kerosene space heaters in use is in the southern United States where the mild winters promote the use of UKSHs as a supplement to or in place of a central heating system. The estimates presented in Figure 7 represent the 1986-87 heating season, as projected from values reported in the April 1984 - March 1985 Residential Energy Consumption Survey (RECS), Part 1, conducted by the U.S. Energy Information Administration. (A copy of the relevant RECS report section is included in Appendix A of this report).

For the 1984-85 heating season, RECS reported a total of 5.3 million households with one or more unvented kerosene space heaters in use with the following distribution by region:

Northeast - 1.3 million
North Central - 1.2 million
South - 2.5 million
West - 0.2 million

RECS also reported separately the number of households using UKSHs as a primary source and secondary source of space heating. Of those who use UKSHs as a primary source of heating, 80 percent are located in the southern region. In the South, the majority, 79 percent, of those using fuel oil or kerosene as a main source of heat use this source to heat less than 2000 square feet. Nationally, this figure is 75 percent. Also, approximately 80 percent of those using kerosene nationwide occupy multifamily dwelling units or mobile homes. Though these figures relate to kerosene consumption, Applied Management Sciences utilized them to develop an estimate of the number of households having two or more UKSHs (the point being that most dwelling units which use kerosene for primary heating tend to be small, and therefore are likely to have only one UKSH). The most popular size of UKSH (20,000 BTU/hour) will heat about 1000 square feet of floor space. From this, it is estimated that there is one UKSH for 80 percent of those households using unvented kerosene space heaters as the main source of heat, and two for the remaining 20 percent. The resulting estimate of the number of unvented kerosene space heaters in use for 1984-85 by region is:

North East - 1.35 million
North Central - 1.23 million
South - 2.55 million
West - 0.20 million

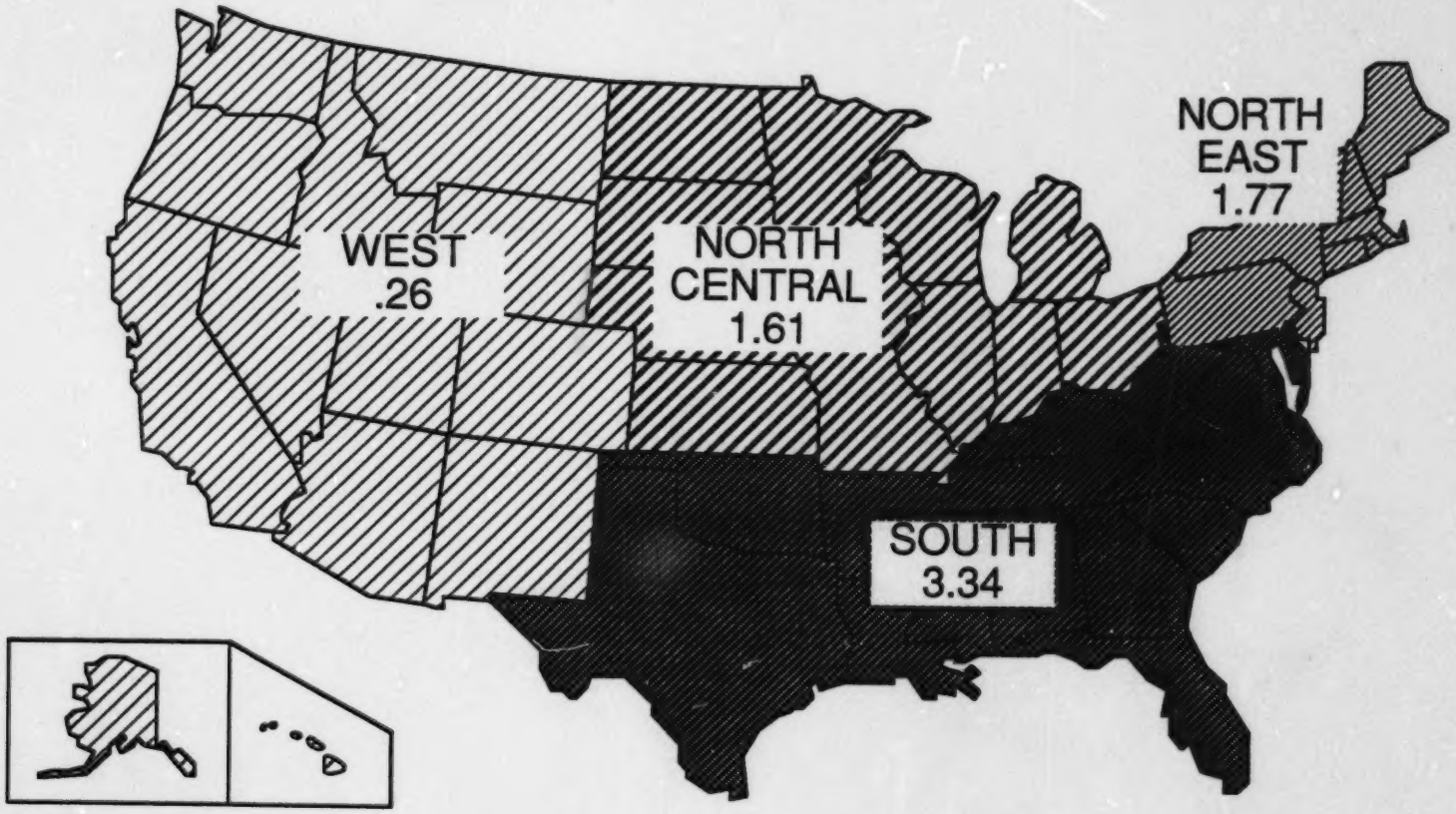

FIGURE 7: ESTIMATED PORTABLE KEROSENE HEATER POPULATION IN USE, 1987 (MILLION UNITS)

SOURCE: EIA: RESIDENTIAL ENERGY CONSUMPTION SURVEY: PART 1, APPLIED MANAGEMENT SCIENCES ANALYSIS

From the data listed in Section 4 of this analysis, the estimated annual sales rate of 825,000 heaters/year was used to project the 1984-85 RECS data to comparable 1987 figures. The 825,000 heaters/year figure was distributed regionally based on each region's 1984-85 share of the total volume of heaters in use. The projected national total is 6.99 million unvented kerosene space heaters in use for the 1986-87 heating season.

The Residential Energy Consumption Survey was used as the primary source of data since it is a nationally-based statistical survey that posed specific questions concerning residential kerosene use and the use of unvented kerosene space heaters. By comparison, a recent survey (the survey itself completed in April 1988) done by the Consumer Product Safety Commission resulted in an approximate figure of 7.1 million heaters currently in use nationally. On a subregional level, the Tennessee Valley Authority reports that 1.6 percent of households in their service area (43,920 households) use UKSHs as a primary source of heating. This figure is consistent with the RECS data which reported 0.49 million households in the southern region as a whole in 1984 used unvented kerosene space heaters for primary heating.

Data on the state level are unavailable or were not at a level of detail sufficient to derive the required estimates of the number of unvented kerosene space heaters. Utility surveys tend to concentrate on the use of the major energy sources -- electricity and natural gas. State level energy use data tends to group kerosene with other energy sources, such as fuel oil, or if kerosene consumption is given, other end uses are included. For these reasons, Applied Management Sciences based its estimates on the RECS data, and benchmarked these estimates against the CPSC and TVA estimates.

USAGE PATTERNS

Before discussing the use of unvented kerosene space heaters, it is best to indicate the varying end uses of kerosene since some of the values shown in this report are derived from data on all uses of kerosene. There are two grades of kerosene: K-2, which has a sulphur content too high for unvented use; and K-1, which can be used in unvented combustion. The major end use of kerosene, about 97 percent for both K-1 and K-2, is space heating. Additionally, kerosene can be used to extend the thicker fuel oils in cold weather and it can be used directly in systems designed for the lighter grade fuel oils. Other uses include hot water heating and in very few instances, in cooking stoves. Primary indicators of unvented kerosene space heater usage were determined to be climate, household income level, and the cost of operating a central heating system.

Statistics indicate that UKSHs are used predominately in the South by households who earn less than $15,000 per year, and live in multifamily dwellings or mobile homes. The estimated hours of UKSH usage per day during a heating season is shown in Figure 8. Eighty percent of households which use UKSHs as the primary heating source are located in the South. Since the heaters are used for primary heating, they are used for longer periods of time. On a national level, households using UKSHs as a primary heating source utilize an average of 160 gallons per household per year. In comparison, households using UKSHs as a source of secondary or supplemental heating utilize an average of 68 gallons per household per year.

To derive the estimates presented in Figure 8, data on the fuel consumption of UKSHs were required. Table 6 shows data from vendor literature on selected heaters produced by the major manufacturers. The convective type unit tends to consume more fuel (0.113 gal/hr) than the radiant (0.076 gal/hr), thereby necessitating estimates of the popularity of each type to obtain an average gallons per hour value. An analysis similar to that used in Section 4 was employed to estimate this split. The top-selling model was assumed to occupy twice the average percentage of the brand's sales, unless the number of models per brand was fewer than five, in which case the top model

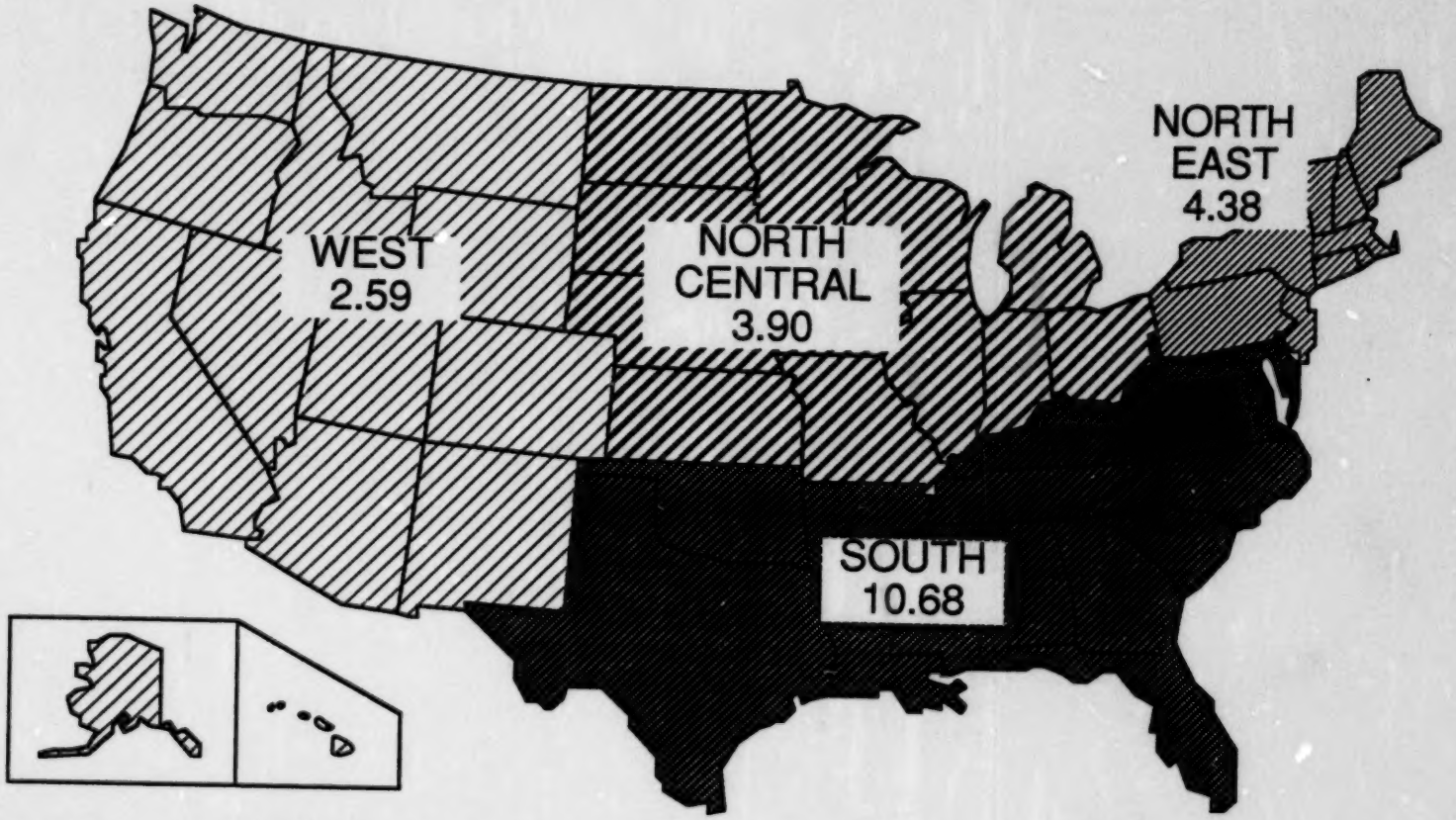

FIGURE 8: ESTIMATED HOURS USED PER DAY DURING THE HEATING SEASON FOR HOUSEHOLDS USING A PORTABLE KEROSENE HEATER AS A SECONDARY SOURCE OF HEATING*

* SOURCE SURVEY DATA HAD TOO FEW OBSERVATIONS OF THOSE USING PORTABLE HEATERS FOR THE MAIN SOURCE OF HEATING TO BE ABLE TO REPORT. THE EXCEPTION IS IN THE SOUTH REGION, WHICH RESULTS IN AN ESTIMATED 16.72 HOURS USED PER DAY WHEN KEROSENE HEATERS ARE USED AS A PRIMARY HEATING SOURCE.

SOURCE: PERSONAL COMMUNICATION, EIA, APPLIED MANAGEMENT SCIENCES ANALYSIS

TABLE 6: AVERAGE CONSUMPTION RATE BY HEATER TYPE

MAKE	MODEL	TYPE	AVG HEATING OUTPUT (BTUh)	TANK CAPACITY (GAL) D	AVERAGE HRS OPERATION PER FILL-UP E	GAL PER HOUR .=D/E
CORONA	12-KDC	CONV	12300	1.06	11.5	0.092
	17-DKC	CONV	17600	1.60	12.0	0.133
	22-DKC	CONV	22600	1.60	9.5	0.168
	FH-321	FAN-CONV	17450	1.30	17.5	0.074
	SX-2E	RAD	10000	0.98	13.0	0.075
	SX-3C	RAD	12600	0.98	10.0	0.098
KEROSUN	DBL. CLEAN 90	CONV/RAD	14350	1.95	19.0	0.103
	OMNI120	CONV	22700	1.99	14.0	0.142
	OMNI 105	CONV	20000	1.95	16.0	0.122
	MOONLIGHTER	CONV/RAD	9300	1.60	28.0	0.057
	RADIENT 36	RAD	10000	1.40	22.0	0.064
	SUNSTREAM	FAN-RAD	10500	1.40	45.0	0.031
	RADIANT 10	RAD	9600	1.92	32.0	0.060
TOYOSTOVE	DC-100	CONV/RAD	14300	1.95	19.0	0.103
	DC-80	CONV/RAD	11450	1.70	20.5	0.083
	DC-60	CONV/RAD	7950	1.70	29.0	0.059
	DR-86	RAD	7950	1.40	24.0	0.058
	DR-86F	FAN-RAD	7950	1.40	24.0	0.058
	WC1205R	CONV	22700	1.99	14.0	0.142
	WC105R	CONV	20000	1.95	16.0	0.122
	RAINBOW	CONV/RAD	9300	1.60	28.0	0.057
	RC-37	RAD	10000	1.40	22.5	0.062
	RC-11	RAD	9600	1.92	32.0	0.060
	LR-450	RAD	18750	2.00	16.0	0.125
	LR-350	RAD	12800	1.40	21.5	0.065
ROBESON	2620	CONV	22000	1.90	12.0	0.158
	3-2615-91	CONV/RAD	22500	1.90	12.0	0.158
	3-2615-91	RAD	11000	1.20	16.5	0.073
KEROHEAT	CV2200	CONV	22000	1.90	12.0	0.158
	BT1000	RAD	10000	1.10	15.5	0.071
	BT1100	RAD	10600	1.00	12.0	0.083
ALADDIN	TR4000	CONV	12300	1.06	10.5	0.101
	TR7000	RAD	20500	1.30	9.5	0.137
	TR3000	RAD	10500	0.80	10.5	0.076

SUM OF BOTH TYPES	3.230
AVERAGE OF BOTH TYPES	0.095

SUM OF CONVECTIVE RATE	2.033
AVG OF CONVECTIVE RATE	0.133
SUM OF RADIANT RATE	1.139
AVG OF RADIANT RATE	0.076

sales is 1.5 times the average. This calculation was applied to each brand, keeping the values for the radiant and convective types separate. These percentages were then applied to the estimated sales per brand in order to obtain an estimate of the number of convective and radiant units sold. This computation resulted in a calculated market share of approximately 58 percent convective, 42 percent radiant. These figures resulted in an average consumption rate of 0.0973 gal/hr.

Based upon the data provided by RECS, the yearly gallons per household average for those using unvented kerosene space heaters as the primary source is greater than those using them as a secondary source; therefore, the calculations for consumption were kept separate. The gallons per household value and the gal/hr obtained above were used to estimate the total hours of heater usage per year. Based upon the average heating load hours per region (see Figure 9), the number of days in a heating season was estimated. Hours used per year and days in a heating season resulted in the values presented in Figure 8. These estimates indicate that the major users of UKSHs are households in the South and Northeast census regions. This usage pattern is primarily due to the climatic conditions that exist, and secondarily to the economic status of each region. The southern region is comprised of states that have predominately mild winters. Therefore UKSHs are used as both a primary and secondary (supplemental) heating source because of the low initial purchase cost. The lower income households generally use more kerosene as the primary heating source, as will be supported later in this Section. The Northeast and North Central regions tend to use the unvented kerosene space heaters to supplement central heating; using the heaters in the occupied areas and turning the thermostat down for the remainder of the residence, or using the units to increase an inadequate heating capacity. The West contains only about four percent of the total number of households using UKSHs, and this region uses only 1.7 percent of the kerosene.

Figure 10 provides an indicator of the states that are the major consumers of kerosene for UKSHs. The states that used the most kerosene in 1986 for UKSHs are estimated to be Ohio, followed by North Carolina and Virginia. This information is from the State Energy Data Report (SEDR) containing estimates of state level values for total kerosene consumption by residences for 1960-1986. Since these were total values, an approximation was made for the kerosene usage for UKSHs only, since kerosene has other end uses. This involved using the consumption per region for kerosene usage by UKSHs and for all kerosene usage as reported in RECS for 1984-85. Applying this ratio to each state's total residential kerosene consumption in the region resulted in the values illustrated in Figure 10. The SEDR report indicates a six percent decrease in total residential kerosene consumption from 1984 to 1986; the total of the kerosene use for Figure 10 indicates an 11 percent decrease from the RECS 1984-85 value (417 million gallons to 371 million gallons). This approximation is valid due to the +/- 10% accuracy between the regional consumption figures reported in RECS and the value obtained by adding up the state values (of the SEDR) that comprise each region.

Figure 11 shows the average national kerosene consumption by type of home and geographical location. There is little difference in consumption between the various locations of the residences, though the consumption in the city is less, which is to be expected since some cities have fire codes prohibiting UKSH use. This figure also illustrates the heavy use of kerosene in mobile homes and multifamily dwellings.

The values shown in Figure 11 represent all residential end uses of kerosene. The percentages are estimated to be similar for the kerosene consumed by UKSHs, but this cannot be validated. The estimated UKSH usage in multifamily dwellings may therefore be overstated since it is likely that vented kerosene central furnaces could account for some of this consumption.

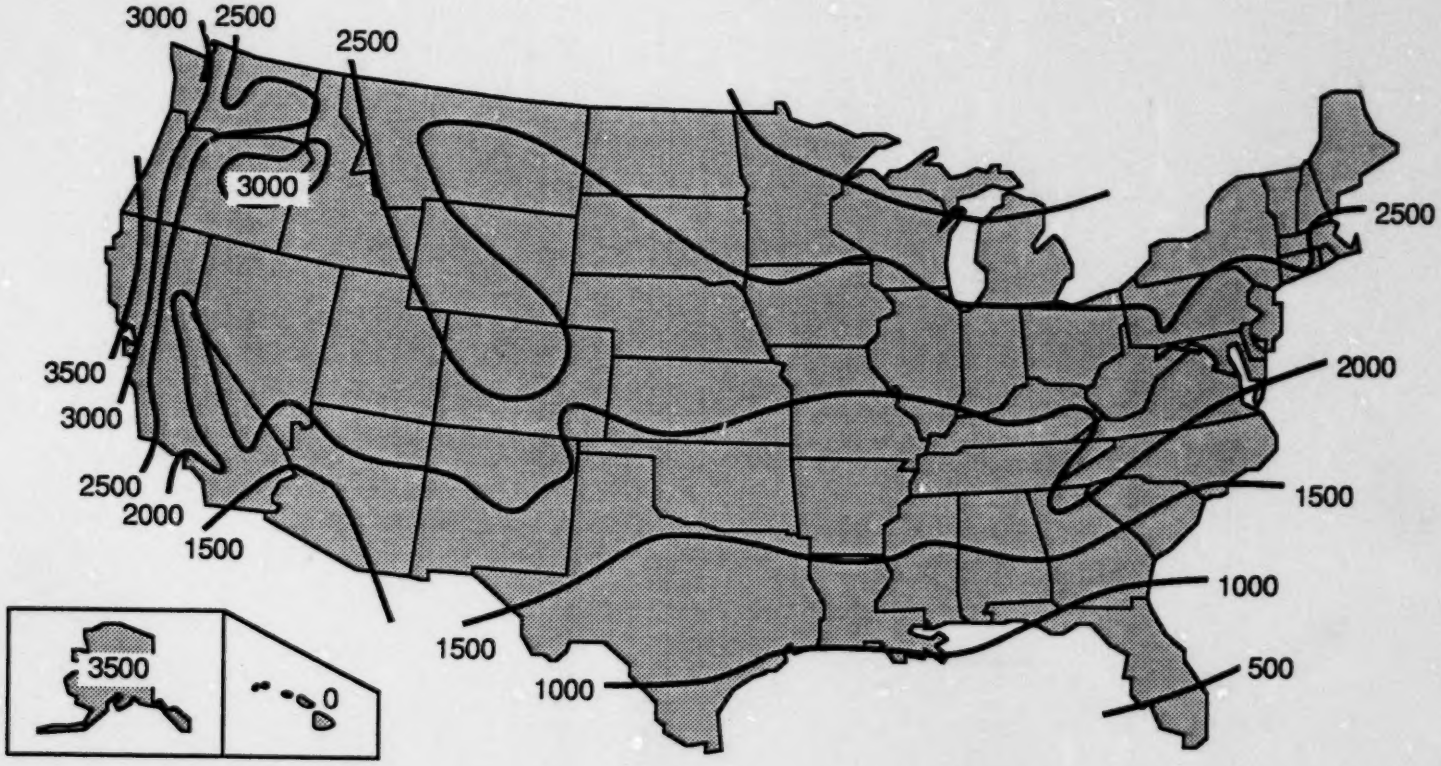

FIGURE 9: HEATING LOAD HOURS FOR THE UNITED STATES

SOURCE: GAS APPLIANCE MANUFACTURERS ASSOCIATION, APRIL 1988 CONSUMERS DIRECTORY OF CERTIFIED EFFICIENCY RATINGS FOR RESIDENTIAL HEATING AND WATER HEATING EQUIPMENT

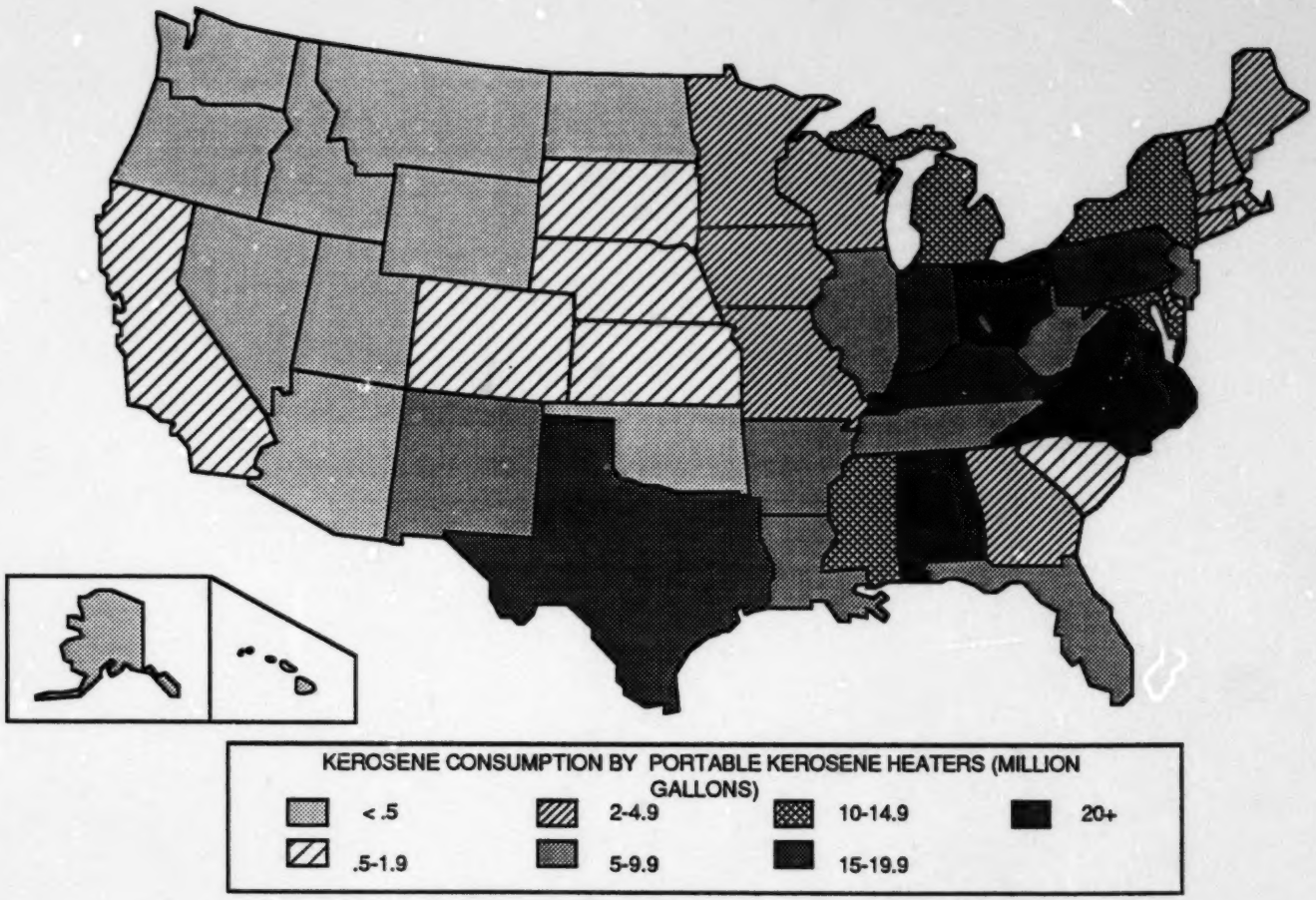

FIGURE 10: ESTIMATED 1986 KEROSENE CONSUMPTION BY PORTABLE KEROSENE HEATERS

SOURCE: SEDR, RECS, APPLIED MANAGEMENT SCIENCES ANALYSIS

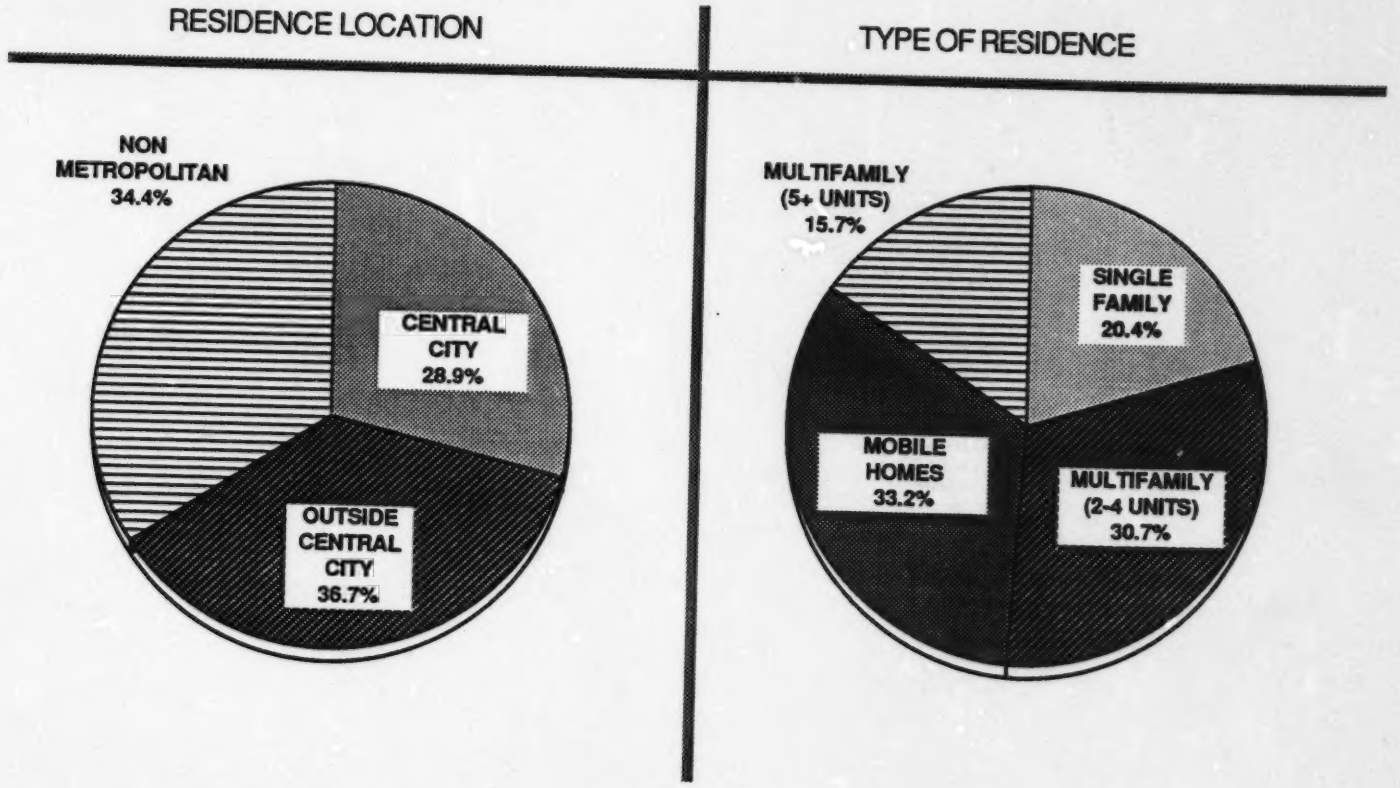

FIGURE 11: AVERAGE NATIONAL KEROSENE CONSUMPTION BY RESIDENCE LOCATION AND TYPE OF RESIDENCE

SOURCE: 28, APPLIED MANAGEMENT SCIENCES ANALYSIS

Figures 12 through 14 indicate the different kerosene usage levels by income level. They show the distribution of kerosene consumption per household by all end uses and by UKSHs used as a secondary source of heating. Each figure is for a particular region. The Western region is not reported because there were negligible cases per income class. These figures indicate the predominant usage of kerosene in the lower income brackets, particularly in the $5-$15,000 annual income range. Though one of the values shown is for all end uses, most of the kerosene is used for space heating; estimated at 97 percent. An interesting fact taken from the RECS report is that the number of kerosene users is about the same between the groups earning less than and more than $20,000, but the consumption is unequally weighted toward the lower income group, which uses about 70 percent of the kerosene. This supports the statements made earlier with regard to the economic factor in UKSH purchases and kerosene consumption. These values were quoted by one of the RECS authors, as the breakdown for consumption from just UKSHs was not available in the published report. The values were reported for all end uses of kerosene only. The secondary source information was taken from the average national breakdown ratio of all uses to secondary, by income level (pg. 15, Part 1 of RECS). Even though the ratio of all uses to secondary source users will vary from region to region, these charts are generally representative of the consumption distribution. Since the consumption was approximately the same in 1986 as 1984, the 1984 family income levels and consumption data should also be representative of 1986 figures.

NORTHEAST CENSUS REGION

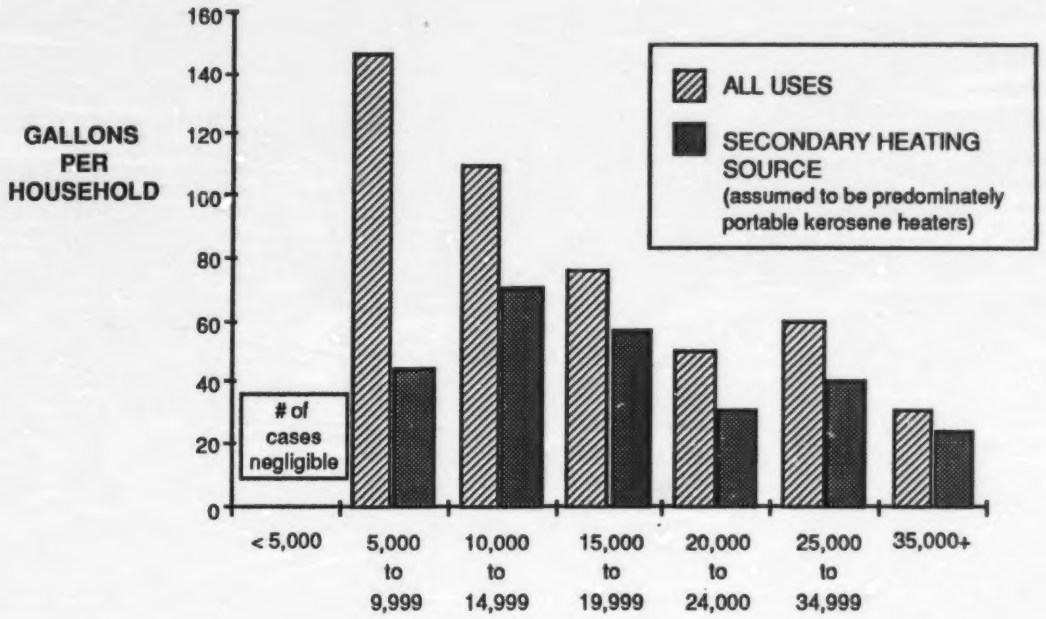

FIGURE 12: TOTAL ANNUAL KEROSENE CONSUMPTION BY INCOME GROUP AND HEATING DEPENDENCY

SOURCE: 28; APPLIED MANAGEMENT SCIENCES ANALYSIS

NORTH CENTRAL CENSUS REGION

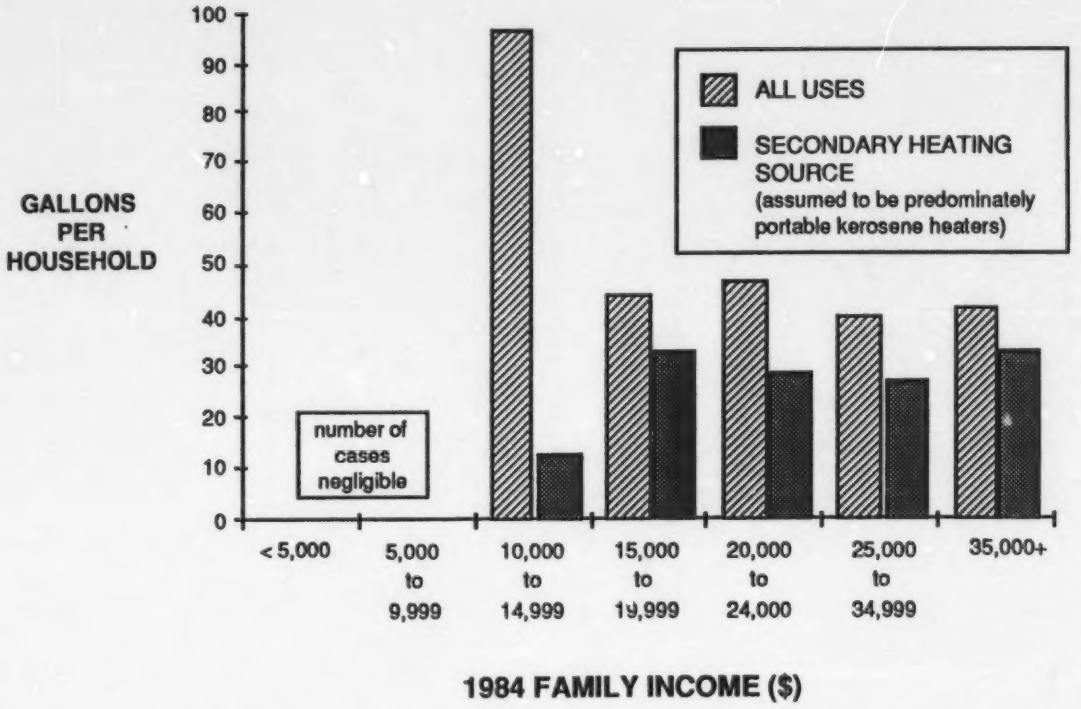

FIGURE 13: TOTAL ANNUAL KEROSENE CONSUMPTION BY INCOME GROUP AND HEATING DEPENDENCY

SOURCE: 28, APPLIED MANAGEMENT SCIENCES ANALYSIS

SOUTH CENSUS REGION

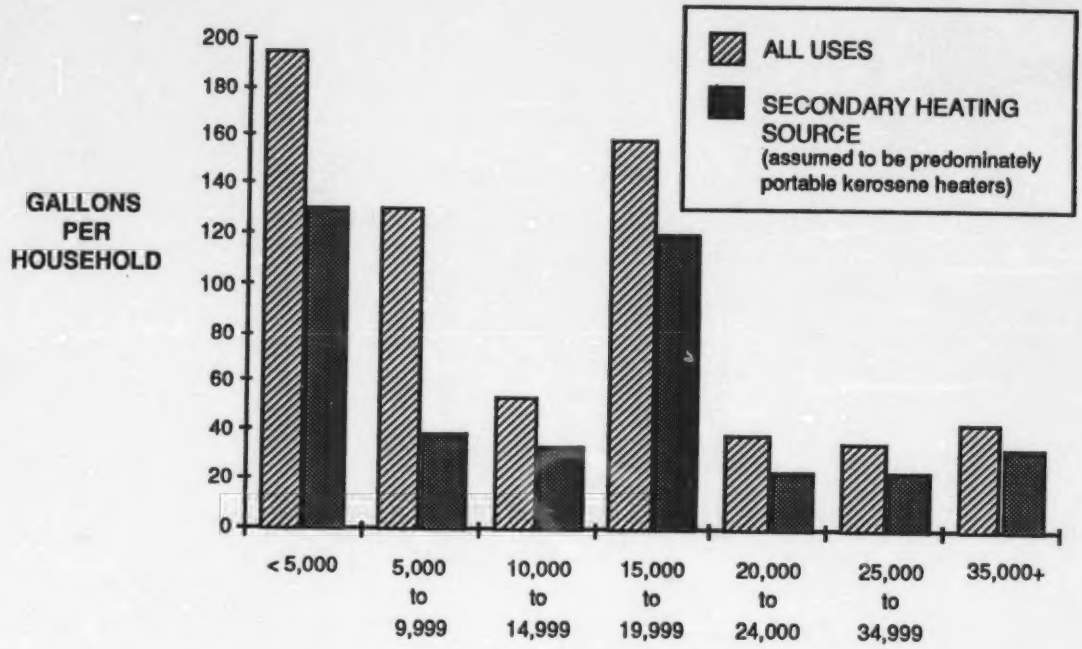

FIGURE 14: TOTAL ANNUAL KEROSENE CONSUMPTION BY INCOME GROUP AND HEATING DEPENDENCY

SOURCE: 28, APPLIED MANAGEMENT SCIENCES ANALYSIS

SECTION 7

MANUFACTURING TRENDS

Three factors will influence the demand for unvented kerosene space heaters in the course of the next five to ten years. The primary factor influencing demand is the price of alternative traditional energy sources such as electricity, natural gas, and fuel oil as compared to the price of operating a unvented kerosene space heater. Second, the initial price of the heater itself is a factor; continued low cost is essential. Finally, regulatory concerns will be an important consideration. There are existing regulations and bans on the use of UKSHs; most of these relate to fire hazards. Additional information and publicity is also being generated concerning potential indoor pollution issues associated with UKSH usage. Based upon these three factors, it is expected that the demand for unvented kerosene space heaters will decrease slightly in the next five to ten years. Other energy sources are expected to maintain or decrease in price; the base price of unvented kerosene space heaters has been increasing as the cost of meeting mandated standards increases; and, media attention given to pollution hazards endemic to unvented kerosene space heaters may cause a decline in sales. All of these influences may provide a disincentive to the purchase of unvented kerosene space heaters.

As noted in Section 3 of this report, a few of the newest technologies are the Double Clean model by Toyotomi, which uses a dual combustion process, and the wickless models manufactured by Toyotomi and Corona. Both of these types feature cleaner emissions and advanced controls, but have higher initial purchase costs. This higher cost offsets the new technology features on the American market. Recent conversations with two manufacturers of unvented kerosene space heaters revealed that even though the new technologies sell well, their sales are not predicted to exceed those of the current "standard" convective type unit. It would appear that the higher technology units appeal to the higher income buyers, but the lower income groups, where the most kerosene is used, are concerned with minimizing initial costs and are thus likely to continue to purchase the lower cost standard convective and radiant units, which are usually wick-fed and have single stage combustion.

The following data indicate the price differences between a "standard" convective or radiant UKSH and the newer, high technology "wickless" and "double combustion" type of heater with similar heating capacity.

HEATER TYPE	AVG. COST
Standard (wick-fed single stage combustion)	$140
Double Clean (dual combustion)	$260
Laser Clean (wickless)	$530

SECTION 8

RECOMMENDED KEROSENE HEATERS FOR CHARACTERIZATION

A major goal of this study was to recommend typical unvented kerosene space heater models for laboratory measurement and characterization of emissions. The heaters were to be representative of the recent past (pre-1986/1987), and representative of the near future in terms of the technology utilized.

Based on the research presented in the preceding sections of this report, Applied Management Sciences recommends four categories of unvented kerosene space heaters for characterization. Representative models within each category are also shown. The categories and representative models are as follows:

Category	Representative Model(s)
Convective	Kero-Sun Omni 105 Corona 22DK Kero-Sun Omni 120
Radiant	Robeson 3-2619-91 Toyostove RC37
Dual Combustion	Toyostove Double Clean 100 Kero-Sun Double Clean 90
Wickless	Toyostove Laser Clean LR 450

The best selling convective and radiant models (which for the most part are wick-fed with single stage combustion) would be most representative of the 1986-87 and prior heating seasons. The dual combustion and wickless categories represent recently introduced technologies which may be more representative of the future. It should be reiterated, however, that while the newer dual combustion and wickless models are selling well, they can be substantially more expensive than the standard wick-fed single stage combustion convective and radiant units. Therefore, the latter are expected to continue to dominate the U.S. market for at least the next several years unless costs of the newer technologies can be reduced.

SECTION 9

LITERATURE REVIEW

As part of this study, Applied Management Sciences performed a literature search on unvented kerosene space heater emissions. The results of this search and one recently conducted by EPA on non-technical literature are included in Appendix B. Abstracts of several key articles dealing with unvented kerosene space heater emissions are included below.

6/7/18
1222834

Comparison Of Pollutant Emission Rates From Unvented Kerosene And Gas Space Heaters.

Apte, M.G.; Traynor, G.W.
Lawrence Berkeley Lab., CA (USA)
Managing indoor air for health and energy conservation Atlanta, GA, USA 20 Apr 1986

In this paper the pollutant emission rates of all five types of unvented space heaters are compared. Pollutant emission rates for carbon dioxide, carbon monoxide (CO), nitric oxide, nitrogen dioxide (NO_2), formaldehyde, and submicron suspended particles were measured. Special emphasis is placed on CO and NO_2 emissions. Pollution measurements were made in a 27-mT environmental chamber and emission rates were calculated using a mass-balance model. Emission rates for propane and natural gas space heaters were similar. Emissions from the various types of heaters fall into three distinct groups. The groups are better characterized by burner design than by type of fuel used. Radiant unvented kerosene space heaters and infrared UVGSHs constitute one group; convective unvented kerosene space heaters and UVGSHs the second, and two-stage unvented kerosene space heaters the third group. When groups are compared, emission rates vary by an order of magnitude for carbon monoxide and for nitrogen dioxide. The two-stage unvented kerosene space heaters emitted the least CO and also the least NO_2 per unit of fuel energy consumed. The radiant/infrared heaters emitted the most CO, and the convective heaters emitted the most NO_2. The effects of various operation parameters such as the wick height for unvented kerosene space heaters and the air shutter adjustment for gas heaters are discussed. Convective UVGSHs operating at half input were found to have lower emission rates on average than when operating at full input. Some maltuned convective heaters were found to emit more CO and NO_2 on average when they were operated with lowered wicks.

6/7/20
1159329

Selected Organic Pollutant Emissions From Unvented Kerosene Heaters

Traynor, G.W.; Apte, M.G.; Sokol, H.A.; Chuang, J.C.; Mumford, J.L.
Lawrence Berkeley Lab., CA; Battelle Columbus Labs., OH.
Analytical and Structural Chemistry Center; Environmental Protection Agency, Research Triangle Park, NC. Health Effects Research Lab.
Air Pollution Control Association annual meeting and exhibition Minneapolis, MN 22 Jun 1986

This study has confirmed the results of other studies, i.e., that the kerosene combustion process can emit PAHs and nitrated-PAHs. In addition, unvented kerosene space heaters were found to emit many other organic compounds, including aliphatic hydrocarbons, alcohols, and

keytones; phthalates; alkyl benzenes; and pentachlorophenol. Additional analysis is needed to correlate these results with health-effects data to determine the risk associated with these organic emissions. PAH and nitrated-PAH emissions are sufficiently important to justify additional quantitative studies; furthermore, examinations of other organic compounds of toxicological significance and of unvented combustion sources should be expanded. One very important observation of this study was that some estimates of the indoor reactivity rates for some SVOCs were higher than 2h. This implies that reactivity rates for some SVOCs are more important than ventilation rates for determining indoor concentrations. Clearly, this indicates that future studies must quantify the indoor reactivity process for individual SVOCs in order to gain insight into potential indoor exposures to these compounds.

6/7/22
1122443

Comparative Study Of Combustion In Kerosene Heaters

Lionel, T.; Martin, R.J.; Brown, N.J.
Lawrence Berkeley Lab., CA
Environ. Sci. Technol. v 20:1 Jan 1986

The combustion characteristics of radiant, convective, and multistage kerosene heaters have been determined and compared. Two types of experiments were conducted. In the first of these, composition and temperature were measured as a function of axial position in the heater to determine the progress of combustion. In the second type, composition, fuel consumption rate, temperature, pressure, and exhaust stream mass flow rate were measured in an exhaust manifold to ascertain the effect of heater type and heater operating conditions on exhaust gas composition. Fuel consumption was sensitive to wick height, wick age, and volume of fuel in the tank. Heater design strongly influenced emission rates. The convective and multi-stage heaters produced the smallest amounts of CO (per Kilojoule). The radiant heater produced the largest amounts of CO and the smallest amounts of NO/subx/. The convective heater produced the largest amounts of NO/sub x/. Results were compared with chamber and other laboratory studies, and agreement among the various studies was found to be quite satisfactory.

1/7/6
0124245

Reduction Of Carbon Monoxide From Domestic Kerosene Heaters

Rashidi, M.; Massoudi M. S.; Shadman F.
Arya-Mehr Univ. of Technology, Iran,
J Env Science & Health-Env Science & Engineering, 1977, V12, N3

Research report an experiment was conducted to develop methods or devices for reducing carbon monoxide concentrations caused by kerosene heaters. A device applying the idea of both thermal reactor and catalysis was developed; This proved very effective in oxidizing CO and unburnt hydrocarbons emitted by a wick-type kerosene heater. The reduction in CO level was achieved by allowing longer reaction time for complete combustion and slower cooling of the products. Using the device, reduction of CO to one-sixth of the normal concentration was achieved. However, nitrogen oxides in the combustion products increased by about 10%. Use of reducing or oxidizing catalytic agents in addition to the device did not prove effective in further reducing the undesirable emissions.

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4. Dun & Bradstreet Principal International Businesses (1988)
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13. Underwriters Laboratory Standard 647; September 1986
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16. same as 15. except Part 2, Regional Data
17. same as 15. except Trends in Consumption and Expenditures 1978-1984
18. Survey on Supplemental Heating Equipment; June 17, 1988; Abt Associates Inc. under contract to the Consumer Product Safety Commission

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20. G. Potter, consultant to KHMA; May 1988
21. W. Porter/D. Ray, Consumer Product Safety Commission; May 1988
22. E. Shaw, Department of Commerce (USG); May 1988

Sources (personal communication, cont.)

23. J. Brandon, Intl. Trade Commission (USG); May 1988
24. Mary Lynn Fessler, Census Bureau
25. Mark Futrell, Governors Energy Office, State of Florida
26. Chris Angle, Corona USA
27. Barry Sullivan, Toyotomi USA
28. Wendell Thompson, Energy Information Administration
29. Chris Morgenson, North Carolina Energy Commission
30. Bob Smith, Met Pro, Corp.
31. Jim Williams, American Petroleum Institute

Sources (manufacturers/distributors contacted)

32. Toyotomi USA, Corona USA, Robeson Industries, RMC Intl., Aladdin Intl., Schwank Inc., Uchida Yoko Co., Desa Intl. Inc.

Sources (local dealers contacted)

33. Hechingers, K-Mart, Sears, Wal-Mart, Montgomery Ward, Richmond Power Equipment Co., Hardware City, Thos W. Perry Inc.

34. California Energy Commission

35. Housing and Urban Development (HUD)

36. National Association of Home Builders (NAHB)

37. Product brochures: Keromate, Toyostove, Met Pro, Corona, Kero-Sun, Robeson, Keroheat (RMC International, Ltd.), Aladdin

APPENDIX A

RECS SECTION ON KEROSENE HEATERS
(Residential Energy Consumption Survey)

Households Spent Nearly a Billion Dollars on Kerosene in 1984

U.S. households paid out 921 (±239) million dollars for kerosene in 1984 (Table 6). Half (54.7 [±11.9] percent) of these expenditures were made by households earning less than $15,000 in 1984 although only 36.3 (±5.9) percent of all kerosene users fall below this income level. The reason for this disproportionate share of expenditures for lower-income groups is discussed below. The average price paid for kerosene in 1984 was $1.21 (±0.02) per gallon.

Table 6. U.S. Residential Purchases of and Expenditures for Kerosene--April 1984 Through March 1985

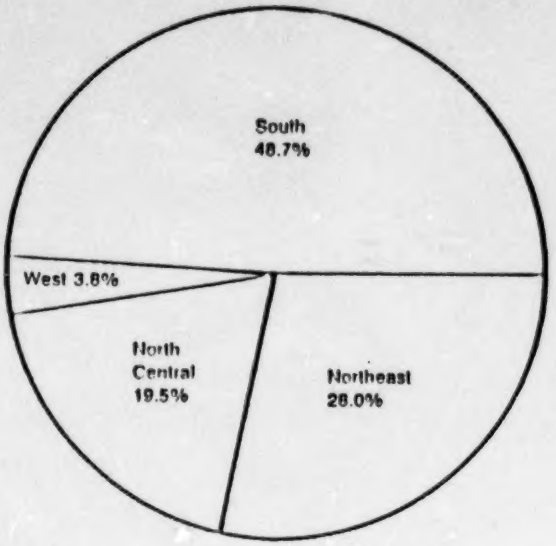
Household Characteristics	Number of Households (million)	Total Amount Purchased		Average Consumption (gallons per household)	Expenditures (million dollars)	Price (dollars per gallon)
		(trillion Btu)	(million gallons)			
Total Households	6.4	102	759	119	921	1.21
Census Region						
Northeast	1.9	37	271	152	328	1.21
North Central	1.2	10	71	57	90	1.27
South	3.1	55	406	130	489	1.21
West	.2	1	11	44	14	1.28
Family Income						
Less than $5,000	.5	16	130	246	155	1.19
$5,000 to $9,999	1.0	27	198	207	234	1.18
$10,000 to $14,999	.8	13	95	113	117	1.23
$15,000 to $19,999	.7	16	120	169	144	1.21
$20,000 to $24,999	.7	7	53	71	86	1.25
$25,000 to $34,999	1.1	10	73	68	91	1.25
$35,000 or More	1.5	12	90	59	114	1.26

Note: Data may not sum to totals due to rounding.
Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

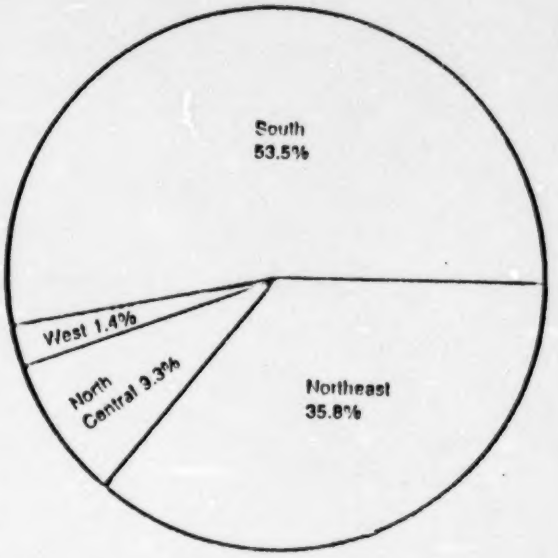
Most Kerosene Is Purchased in the South and Northeast Census Regions

Most residential kerosene (89.3 [±10.7] percent) was purchased in the South and Northeast Census Regions (Table 6, Figure 3). Of a total 759 (±197) *million gallons purchased for home use between April 1984 and March 1985*, 406 (±137) million gallons were purchased in the South Region and 271 (±112) million gallons were purchased in the Northeast Region. The remainder, 82 (±36) million gallons, were purchased in the West and North Central Regions. One reason for this greater consumption in the South and Northeast is that these two regions contain the majority of households that use kerosene (76.7 [±6.1] percent), but another reason is that the consumption per household is also greater in these regions (Table 6).

Figure 3. Use of Kerosene in U.S. Households by Census Region



Households Using Kerosene



Gallons of Kerosene Purchased

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

Portable Kerosene Heaters Have Increased in Popularity

Portable kerosene heaters have become more common in recent years. The number of households with one or more of these heating units increased from 2.8 (±0.6) million households in 1982 to 5.3 (±0.8) million households in 1984. These heaters can be used to heat a small part of the home to a comfortable temperature while the remainder of the home is cooler. This kind of heating strategy may save total heating costs by heating only part of the home to a desired comfort level.

Among households that have one or more portable kerosene heaters, the average annual purchase of kerosene is among the highest in the South Region--95 (±27) gallons (Table 7). The fact that average kerosene usage in the South Region, where the weather is mild, is not lower than the average usage in the North Regions, suggests that the way these heaters are used may be more important than the weather in determining the purchase of kerosene. For example, some households use their portable kerosene heaters as their main source of heat. Most (80 [±15] percent) of these households are in the South Region, which helps explain why average purchases of kerosene in the South Region are among the highest in the country. Households reporting the use of a portable kerosene heater as the main heating source, purchased an average of 160 (±72) gallons in 1984, while those reporting use of the heater as a secondary heating source averaged 68 (±15) gallons purchased during the year (Table 8).

Table 7. Purchases of Kerosene by Households with Portable Kerosene Heaters--April 1984 Through March 1985

Census Region	Number of Households (million)	Total Consumption (million gallons)	Average Consumption (gallons per household)
United States	5.3	417	79
Northeast	1.3	101	75
North Central	1.2	70	57
South	2.5	239	95
West	.2	7	36

Note: Data may not sum to totals due to rounding.
Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

Table 8. Use of Kerosene Among Households Having One or More Portable Kerosene Heaters in November 1984

	Gallons Purchased April 1984 through March 1985		
	All Households	Households Using the Heaters as:	
		Main Source of Heat	Secondary Source of Heat
Number of Households (millions)	5.3	0.8	4.7
Average Gallons Purchased	79	160	68
Percentage of Households Purchasing--			
Fewer than 25 gallons	39	2	44
25 to 49 gallons	17	18	17
50 to 99 gallons	21	24	21
100 to 499 gallons	20	54	16
500 or more gallons	3	3	3
Total	100	100	100

Note: Data may not sum to totals due to rounding.
Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

Kerosene Equally Popular Among All Income Levels, But Average Consumption Is Lowest Among Higher Income Levels

The use of kerosene occurred at essentially the same rate among all income levels of the U.S. society from April 1984 through March 1985 (Table 9). Among the lowest income group, 6.7 (±2.8) percent used kerosene and among the highest income group, 8.2 (±2.1) percent used kerosene. Roughly half (52.6 [±7.3] percent) of all kerosene-using households earned $20,000 or more in 1984. These facts indicate that kerosene is equally likely to be used as a heating fuel in the lower- and higher-income groups.

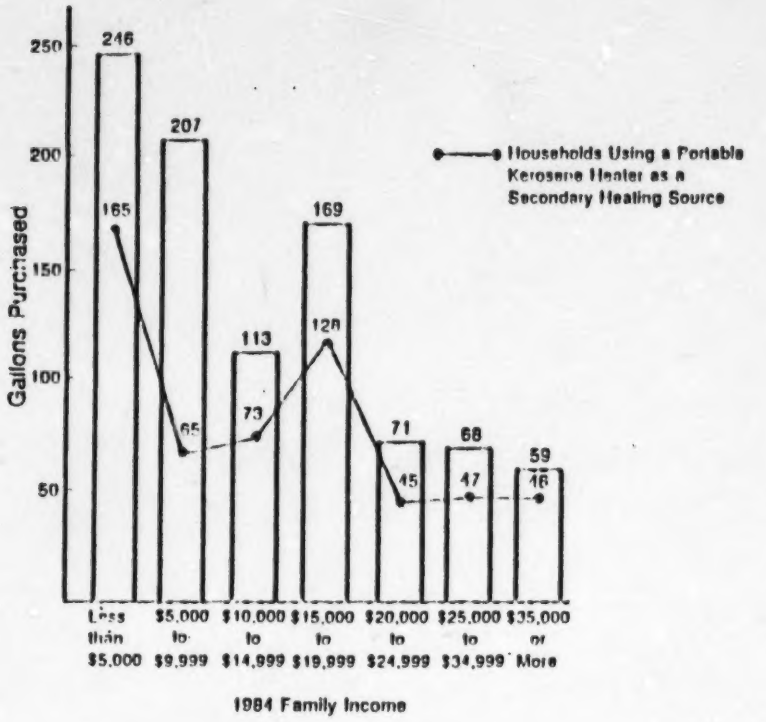
What does distinguish the income groups is the amount of kerosene each purchases. Although households earning $20,000 or more made up about half of all kerosene-using households, as a group they purchased only 28.5 (±10.0) percent of the kerosene during the survey period. The average number of gallons of kerosene purchased decreases from the lower- to higher-income groups (Figure 4). One reason for this is that lower-income groups used kerosene as a main heating fuel more often than the higher-income groups. Lower-income households also purchased more kerosene for use in portable kerosene heaters as a secondary source of heat. Low-income groups purchased an average of 101 (±31) gallons in 1984 versus 46 (±12) gallons for higher-income households ($20,000 and over), indicating a greater reliance on kerosene as a secondary source of heating among the low-income groups.

Table 9. Use of Kerosene by Income Groups, April 1984 Through March 1985

Income Group	Percentage of Income Group Using Kerosene	Percentage of Kerosene Users	Percentage of Total Gallons of Kerosene Purchased
Total	7.4	100.0	100.0
1984 Family Income			
Less than $5,000	6.7	8.2	17.1
$5,000 to $9,999	6.8	14.9	26.1
$10,000 to $14,999	6.4	13.2	12.5
$15,000 to $19,999	7.9	11.1	15.8
$20,000 to $24,999	8.6	11.6	6.9
$25,000 to $34,999	7.0	16.9	9.7
$35,000 or More	8.2	24.1	11.9

Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

Figure 4. Average Gallons of Kerosene Purchased by Income Groups



Source: Energy Information Administration, Office of Energy Markets and End Use, Form EIA-457, The 1984 Residential Energy Consumption Survey.

APPENDIX B

LITERATURE ABSTRACTS

The following Abstracts were obtained from Enviroline, Environment Abstracts, Bowker A&I Publishing, R.R. Bowker, 245 W. 17 St., NYC 10011, Copyright 1988, Reed Publishing USA.*

5/7/1 (Item 1 from file: 103)
1517562 ERA-13:030464, EDB-88:090618 TIC Accession No.: DE88008364
A brief review of control measures for indoor formaldehyde
Matthews, T.G.
Oak Ridge National Lab., TN (USA)
American Thoracic Society workshop on indoor environmental controls and lung disease, Santa Fe, NM, USA 24 Mar 1988
1988. 5 p.
Report No.: CONF-880382-1; CONF-880382-
Contract No.: AC05-84OR21400
Journal Announcement: NTS
Document Type: Report; Conference literature
Language: English
Subfile: NTS (NTIS); ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

Indoor environments contain a variety of consumer and construction products that emit formaldehyde (CH/sub 2/O) vapor. The strongest CH/sub 2/O emitters are typically particleboard underlayment and industrial particleboard, hardwood plywood paneling, urea-formaldehyde foam insulation, and medium density fiberboard, all of which contain urea-formaldehyde (UF) resins. The contribution of individual products to indoor CH/sub 2/O levels depends on several parameters, including the quantity and age of the product, building ventilation rate, presence of permeation barriers, temperature (T), relative humidity (RH), and CH/sub 2/O vapor concentration resulting from all of the CH/sub 2/O emitters (1,3-8). Combustion sources (e.g., kerosene heaters, gas stoves and cigarettes), carpet and carpet padding, resilient flooring (e.g., linoleum), gypsum board, non-apparel and apparel textiles, ceiling tiles, fibrous glass insulation and softwood plywood subflooring are generally weak emitters that do not contribute significantly to steady-state, indoor CH/sub 2/O levels. Control measures exist to reduce CH/sub 2/O emissions from consumer and construction products during their manufacturer and in post-installation applications. This note summarized the effectiveness of the following subset of post-installation control measures: product aging, installations of permeation barriers (i.e., flooring) and increased building ventilation. 14 refs.

5/7/2 (Item 2 from file: 103)
1489040 ERA-13:019657, EDB-88:062095 TIC Accession No.: DE88004513
Human exposure to mutagens from indoor combustion sources
Indoor air '87: Volume 1, Volatile organic compounds, combustion gases, particles and fibres, microbiological agents
Lewtas, J.; Claxton, L.D.; Mumford, J.L.; Seifert, B.; Esdorn, H.; Fischer, M.; Rueden, H.; Wegner, J. (eds.)
Environmental Protection Agency, Research Triangle Park, NC
Bundesgesundheitsamt, Berlin (Germany, F.R.). Inst. fuer Wasser-, Boden- und Lufthygiene; Technische Univ. Berlin (Germany, F.R.). Hermann Rietschel Inst. of Heating and Air Conditioning; Freie Univ. Berlin (Germany, F.R.). Inst. of Hygiene
INDOOR AIR '87: 4th international conference on indoor air quality and climate Berlin, F.R. Germany 17 Aug 1987

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1987. 473-477 p.
Report No.: DOE/ER/60493-1-Vol.1; CONF-870853-Vol.1
Journal Announcement: EDB8803
Availability: NTIS, PC A; 3.
Document Type: Analytic of a Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: Germany, Federal Republic of
Work Location: United States

The authors have measured human exposure to mutagens, using indoor medium-volume samplers and personal samplers, in targeted field studies of homes in the US. The combustion sources included in these studies were wood stoves, fireplaces, gas appliances, cooking, and tobacco smoking. These studies demonstrate that the presence of environmental tobacco smoke (ETS) consistently results in human exposure to mutagens which are significantly higher than outdoor air or non-smoking indoor spaces. The mutagenic emission rates from the other indoor combustion sources (e.g., kerosene heaters) as determined in chamber studies are more variable than ETS and are dependent on the combustion source design and operation. Wood stoves and fireplaces result in higher concentrations of mutagens outdoors, which may indirectly influence the concentration of mutagens indoors.

5/7/3 (Item 3 from file: 103)
1487109 ERA-13:019232, EDB-88:060164 TIC Accession No.: DE88004513
Assessment and control of indoor air pollution resulting from wood-burning appliance use
Indoor air '87: Volume 1, Volatile organic compounds, combustion gases, particles and fibres, microbiological agents
Kaarakka, P.; Kanarek, M.S.; Lawrence, J.R.; Seifert, B.; Esdorn, H.; Fischer, M.; Rueden, H.; Wegner, J. (eds.)
Univ. of Wisconsin, Madison
Bundesgesundheitsamt, Berlin (Germany, F.R.). Inst. fuer Wasser-, Boden- und Lufthygiene; Technische Univ. Berlin (Germany, F.R.). Hermann Rietschel Inst. of Heating and Air Conditioning; Freie Univ. Berlin (Germany, F.R.). Inst. of Hygiene
INDOOR AIR '87: 4th international conference on indoor air quality and climate Berlin, F.R. Germany 17 Aug 1987
1987. 425-429 p.
Report No.: DOE/ER/60493-1-Vol.1; CONF-870853-Vol.1
Journal Announcement: EDB8803
Availability: NTIS, PC A; 3.
Document Type: Analytic of a Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: Germany, Federal Republic of
Work Location: United States

A survey of indoor air combustion products has been done in 20 homes with wood burning appliances to identify potential factors which might be involved in the release of pollutants. Homes were selected to be without cigarette smokers, gas cooking stoves and kerosene space heaters. Each home was monitored twice with wood-burner operation and twice without. Participants recorded weight of wood burned, time of loading, damper settings and backdrafting episodes. Indoor levels of measured combustion products were quite low during both burn and non-burn periods. Respirable particulate and carbon monoxide levels were significantly higher in homes with stoves having visible leaks or backdrafting. Indoor NO/sub 2/ levels were significantly higher during wood-burning, however this increase was found to be due to higher outdoor levels and not direct indoor emissions.

5/7/4 (Item 4 from file: 103)
1487084 ERA-13:019207, EDB-88:060139 TIC Accession No.: DE88004513
Macromodel for assessing indoor exposures to combustion-generated pollutants
Indoor air '87: Volume 1, Volatile organic compounds, combustion gases, particles and fibres, microbiological agents
Traynor, G.W.; Aceti, J.C.; Apte, M.G.; Smith, B.V.; Green, L.L.; Smith-Reiser, A.; Novak, K.M.; Moses, D.O.; Seifert, B.; Esdorn, H.; Fischer, M.; Rueden, H.; Wegner, J. (eds.)
Lawrence Berkeley Lab., CA
Bundesgesundheitsamt, Berlin (Germany, F.R.). Inst. fuer Wasser-, Boden- und Lufthygiene; Technische Univ. Berlin (Germany, F.R.). Hermann Rietschel Inst. of Heating and Air Conditioning; Freie Univ. Berlin (Germany, F.R.). Inst. of Hygiene
INDOOR AIR '87: 4th international conference on indoor air quality and climate Berlin, F.R. Germany 17 Aug 1987
1987. 273-277 p.
Report No.: DOE/ER/60493-1-Vol.1; CONF-870853-Vol.1
Journal Announcement: EDB8803
Availability: NTIS, PC A; 3.
Document Type: Analytic of a Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: Germany, Federal Republic of
Work Location: United States

A macromodel for assessing indoor exposures to combustion-generated pollutants is currently under development. Major combustion sources to be modeled include cigarette smoking, gas appliances, unvented kerosene space heaters, and wood stoves. Major inputs to the macromodel include source market penetrations, source usage information, pollutant emission rates, source ventilation characteristics, building stock characteristics, and outdoor pollutant concentrations. The distributions of input parameters are combined using deterministic and Monte Carlo simulation techniques applied to equations primarily based on mass-balance principles. Outputs from the model include distributions of indoor pollutant concentrations versus geographic location, climate, time of year, and/or sources. The macromodel can be used to identify high-exposure populations and information gaps and to conduct parameter sensitivity analyses.

5/7/5 (Item 5 from file: 103)
1487051 ERA-13:019175, EDB-88:060106 TIC Accession No.: DE88004513
Characterization of particle and organic emissions from unvented kerosene space heaters
Indoor air '87: Volume 1, Volatile organic compounds, combustion gases, particles and fibres, microbiological agents
White, J.B.; Leaderer, B.P.; Boone, P.M.; Hammond, S.K.; Seifert, B.; Esdorn, H.; Fischer, M.; Rueden, H.; Wegner, J. (eds.)
Environmental Protection Agency, Research Triangle Park, NC
Bundesgesundheitsamt, Berlin (Germany, F.R.). Inst. fuer Wasser-, Boden- und Lufthygiene; Technische Univ. Berlin (Germany, F.R.). Hermann Rietschel Inst. of Heating and Air Conditioning; Freie Univ. Berlin (Germany, F.R.). Inst. of Hygiene
INDOOR AIR '87: 4th international conference on indoor air quality and climate Berlin, F.R. Germany 17 Aug 1987
1987. 84-88 p.
Report No.: DOE/ER/60493-1-Vol.1; CONF-870853-Vol.1
Journal Announcement: EDB8803
Availability: NTIS, PC A; 3. (NTIS PB87-103015)
Document Type: Analytic of a Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)

Country of Publication: Germany, Federal Republic of
Work Location: United States

Unvented kerosene space heaters are a major source of indoor air contaminants. This paper reports the results from the first phase of a three phase study to characterize and model particle and organic emissions from unvented kerosene space heaters. In the first phase (a screening phase) emissions from 12 heaters, covering a range of design types and BTU ratings, were evaluated during startup and three steady-state operating conditions (normal, low and high flame settings). Aerosol mass, size distribution, extractable mass, bioassay and trace element content as well as conventional gas (CO, NO/sub x/, etc.) measurements were made for all the heaters tested, while VOC's and semivolatiles measurements were made for a subsample of the heaters.

5/7/6 (Item 6 from file: 103)
1463200 GRA-88:92154, EDB-88:036254
Evaluation of a dual-chamber kerosene-heater combustion technology. Topical report, June-December 1985
Kardas, A.
Institute of Gas Technology, Chicago, IL (USA)
Oct 1987. 36 p.
Report No.: PB-88-142146/XAB
Journal Announcement: ERA8802
Availability: NTIS, PC A03/MF A01.
Document Type: Report
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

A kerosene heater equipped with a dual-chamber combustor was procured, tested, and technically evaluated to determine its applicability to natural gas combustion. The kerosene heater was found to have nitric oxide (NO), nitrogen dioxide (NO2), and carbon monoxide (CO) emissions of 0.0)2, 0.006 and 0.02 lb/10W Btu input, respectively, much lower than those of blue-flame natural-gas combustors. A basic study was conducted to understand the interaction between kerosene combustion and the surrounding metal sleeves forming the dual chamber. Combustion characteristics of kerosene and natural gas were compared to formulate potential designs of low-emitting natural gas combustors. Three concepts were developed for low-emitting burners: an atmospheric burner to replace the kerosene wick in the dual chamber; the same concept with a powered vent; and a two-stage system equipped with a powered vent.

5/7/7 (Item 7 from file: 103)
1447083 GRA-88:12000, EDB-88:020137
Characterization of emissions from combustion sources: controlled studies
Tucker, W.G.
Environmental Protection Agency, Research Triangle Park, NC (USA). Air and Energy Engineering Research Lab.
1987. 6 p.
Report No.: PB-88-104146/XAB; EPA-600/J-87/072
Journal Announcement: ERA8801
Availability: NTIS, PC A02/MF A01. (NTIS PB88-104146)
Note: Pub. in Atmospheric Environment, Vol. 21, No. 2, 281-284(Feb 1987)
Document Type: Report
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

This paper summarizes Session I papers (given at the EPA Workshop on Characterization of Contaminant Emissions from Indoor Sources, Chapel Hill, NC, May 1985) that illustrate the progress made to date on characterizing indoor-combustion emissions from unvented space heaters, gas appliances, and sidestream cigarette smoke. The state of knowledge of such emissions and their controllability is summarized by four general statements: (1) Unvented gas-fired appliances are important sources of indoor CO and NOx, but not of organic emissions; (2) Important combustion sources of indoor organics, include smoking and possibly kerosene heaters; (3) The extent of the problems of leakage from vented appliances is simply not known; (4) Indoor combustion sources do not appear to present major problems with controllability, if source removal is an acceptable alternative. From an engineering standpoint, the most-challenging issue is burner design changes for unvented appliances.

5/7/9 (Item 9 from file: 103)
1401277 EDB-87:159571
Nature of the mutagenicity and carcinogenicity of nitrated, aromatic compounds in the environment
Tokiwa, H.; Nakagawa, R.; Horikawa, K.; Ohkubo, A.
Fukuoka Environmental Research Center, Japan
Environ. Health Perspect. (United States) v 73. Aug 1987. 191-199 p.
Coden: EVHPA
Journal Announcement: EDB8710
Document Type: Journal Article
Language: English
Work Location: Japan

Gaseous substances such as nitrogen dioxide (NO2) and sulfur dioxide (SO2) stimulate the process of nitration of polycyclic aromatic hydrocarbons, and the transformation products display a broad spectrum of mutagenicity, genotoxicity, and carcinogenicity. Bacterial mutation by nitroarenes is specific. Tetracyclic nitroarenes are thought to be the most mutagenic compounds in the Salmonella test system, and some are carcinogenic in rats and mice. Furthermore, it was found that the mutational nitroarenes produced mostly DNA damage, which is subject to recombination repair in the rec assay system using Bacillus subtilis. Nitroarenes in the environment seem to be ubiquitous; the majority of the compounds are emitted directly from diesel emissions, kerosene heaters, and gas and liquefied-gas burners or heaters. In nitroarenes induced during incomplete combustion, nitropyrene and nitrofluoranthene derivatives are the most important mutagens/carcinogens for determining the chronic toxicity of nitroarenes overall.

5/7/11 (Item 11 from file: 103)
1400305 ERA-12:048325, EDB-87:158599 TIC Accession No.: DE87013959
Indoor exposure assessment
Applied Science Division Indoor Environment Program: Annual report, FY 1986
Traynor, G.W.; Nero, A.V.; McCann, J.; Brown, S.R.; Aceti, J.C.; Apte, M.A.; Froehlich, D.A.; Horn, L.; Saegebarth, E; Sokol, H.A.; Cairns, E.J.; Grimsrud, D.T.
Lawrence Berkeley Lab., CA (USA)
May 1987. 3.15-3.23 p.
Report No.: LBL-22153
Journal Announcement: EDB8710
Availability: NTIS, PC A03/MF A01; 1.
Document Type: Analytic of a Report; Numerical data
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

The Indoor Exposure Assessment Group (IEAG) is part of the Lawrence Berkeley Laboratory's Indoor Environment Program. The research within the IEAG during FY 1986 had four major research themes: 1) to develop a macromodel to characterize indoor exposures to harmful pollutants; 2) to characterize pollutant emissions from indoor combustion sources; 3) to compile a data base of field measurements of indoor pollutants; and 4) to conduct human risk assessments associated with exposure to indoor air pollutants. Conceptually, projects that are part of the first three research themes supply the exposure data needed to assessing health risks from indoor air pollutants. In FY'86, macromodeling efforts to assess exposures to combustion pollutants were conducted; semivolatile and nonvolatile organic pollutant emissions from unvented kerosene space heaters were characterized; the concentration of indoor pollutants (CIP) data base was expanded; and a preliminary risk assessment of indoor exposures to organic pollutants was conducted. 12 references, 4 tables.

5/7/12 (Item 12 from file: 103)
1390999 EDB-87:149293
Organic vapors and benz-a-pyrene in the indoor air from non vented kerosene heaters and wood burning fireplaces
Pittsburgh conference and exposition on analytical chemistry and applied spectroscopy
Bozzelli, J.W.; Dong, J.I.; Bobenhausen, C.; Mishra, A.
New Jersey Institute of Technology, Newark
38. Pittsburgh conference and exposition on analytical chemistry and applied spectroscopy
Atlantic City, NJ, USA 9 Mar 1987
Publ: American Chemical Society,Washington, DC,
1987. vp p.
Report No.: CONF-870316-
Journal Announcement: EDB8710
Document Type: Analytic of a Book; Conference literature; Numerical data
Language: English
Country of Publication: United States
Work Location: United States

Emissions from non vented kerosene heaters and poorly vented wood burning stoves can significantly effect indoor quality by contributing significant quantities of organic pollutants including volatiles and non volatile species on particulate or room surfaces. The authors have analyzed total organic vapors, specific organics with volatilities ranging from benzene and hexanes through nitrobenzene, benz-a-pyrene on/in airborne particulate, and inorganics CO and CO2 in indoor environments with kerosene heaters and wood burning fireplaces. The method for the analyses of these vapors are presented. A model based on mass balance with known ventilation rates, measured mixing factors and pollutant concentration profiles, is derived to estimate source strengths and desorption rates.

5/7/13 (Item 13 from file: 103)
1385319 ERA-12:044205, EDB-87:143613
Human exposure to mutagens from indoor combustion sources
Lewtas, J.; Claxton, L.D.; Mumford, J.L.
Environmental Protection Agency, Research Triangle Park, NC (USA). Health Effects Research Lab.
May 1987. 9 p.
Report No.: PB-87-191615/XAB; EPA-600/D-87/144
Journal Announcement: EDB8708
Availability: NTIS, PC A02/MF A01.
Document Type: Report
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States

Work Location: United States

The authors measured human exposure to mutagens, using indoor medium-volume samplers and personal samplers, in targeted field studies of homes in the U.S. The combustion sources included in these studies were woodstoves, fireplaces, gas appliances, cooking, and tobacco smoking. These studies demonstrate that the presence of environmental tobacco smoke (ETS) consistently results in human exposure to mutagens which are significantly higher than outdoor air or non-smoking indoor spaces. The mutagenic emission rates from the other indoor combustion sources (e.g., kerosene heaters) as determined in chamber studies are more variable than ETS and are dependent on the combustion source design and operation. Woodstoves and fireplaces result in higher concentrations of mutagens outdoors, which may indirectly influence the concentration of mutagens indoors.

5/7/14 (Item 14 from file: 103)
1384058 NOV-87:070209, ERA-12:044021, EDB-87:142352
Comparison of pollutant emission rates from unvented kerosene and gas space heaters
IAQ '86: Managing indoor air for health and energy conservation
Apte, M.G.; Traynor, G.W.
Indoor Environment Program, Lawrence Berkeley Lab., Univ. of California, Berkeley, CA 94720
Managing indoor air for health and energy conservation Atlanta, GA, USA 20 Apr 1986
Publ: American Society of Heating Refrigeration and Air Cond.,Atlanta, GA
1986. 405-416 p.
Report No.: CONF-860446-
Contract No.: AC03-76SF00098
Journal Announcement: EDB8709
Document Type: Analytic of a Book; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

A wide variety of unvented kerosene and gas space heaters are used in the United States. These include convective and radiant unvented kerosene space heaters and convective and infrared unvented gas space heaters (UVGSH). Unvented gas space heaters can be fueled by natural gas or propane. In addition, two-stage unvented kerosene space heaters have recently become available in the U.S. In this paper the pollutant emission rates of all five types of unvented space heaters are compared. Pollutant emission rates for carbon dioxide, carbon monoxide (CO), nitric oxide, nitrogen dioxide (NO/sub 2/), formaldehyde, and submicron suspended particles were measured. Special emphasis is placed on CO and NO/sub 2/ emissions. Pollutant measurements were made in a 27-m/sup 3/ (950 ft/sup 3/) environmental chamber, and emission rates were calculated using a mass-balance model. Emission rates for propane and natural gas space heaters were similar.

5/7/15 (Item 15 from file: 103)
1239447 EDB-86:194030
Characterization of particle composition, organic vapor constituents, and mutagenicity of indoor air pollutant emissions
Sexton, K.; Webber, L.M.; Hayward, S.B.; Sextro, R.G. California Dept. of Health Services, Berkeley 3. international conference on indoor air quality and climate Stockholm, Sweden 1984
Environ. Int. (United Kingdom) v 12:1-4. 1986. 351-362 p.
Coden: ENVID
Journal Announcement: ERA8612
Document Type: Journal Article; Conference literature; Numerical data
Language: English

Subfile: ERA (Energy Research Abstracts)
Work Location: United States

A joint chamber experiment was carried out by the California Indoor Air Quality Program and Lawrence Berkeley Laboratory to characterize particle and organic vapor emissions from several important indoor sources, including a gas range, tobacco smoking, hamburger frying, a kerosene heater, and selected aerosol spray products. Among the emissions data collected for each source were particle size distributions, particle-phase chemical compositions, volatile organic compounds, and mutagenicity of particles and vapor-phase constituents. Findings were used to assess qualitatively the nature of airborne emissions from each source and to compare emission constituents among source categories. This approach is a necessary first step in evaluating the feasibility of developing unique signatures for individual sources using a broad array of emission characteristics.

5/7/16 (Item 16 from file: 103)
1231187 ERA-12:001631, EDB-86:185770
Measurements of combustion product emission factors of unvented kerosene heaters
Woodring, J.L.; Duffy, T.L.; Davis, J.T.; Bechtold, R.R.
Argonne National Lab., IL
Am. Ind. Hyg. Assoc. J. (United States) v 46:7. Jul 1985. 350-356 p.
Coden: AIHAA
Journal Announcement: EDB8611
Document Type: Journal Article
Language: English
Subfile: ERA (Energy Research Abstracts)
Work Location: United States

Emissions of combustion products from unvented kerosene heaters were measured in an exhaust system used to ventilate the units. Measurements of carbon monoxide, nitrogen dioxide, sulfur dioxide, formaldehyde and particulates are reported and compared with the results of several other studies. Dilution ventilation requirements to maintain occupational and air quality standards are presented.

5/7/17 (Item 17 from file: 103)
1231025 ERA-12:001508, EDB-86:185608
Selected organic pollutant emissions from unvented kerosene heaters
Traynor, G.W.; Apte, M.G.; Sokol, H.A.; Chuang, J.C.; Mumford, J.L.
California Univ., Berkeley (USA). Lawrence Berkeley Lab.
Jul 1986. 22 p.
Report No.: PB-86-21[illegible]443/XAB
Journal Announcement: EDB8610
Availability: NTIS, PC A02/MF A01.
Document Type: Report
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

An exploratory study was performed to assess the semivolatile and nonvolatile organic-compound emissions from unvented kerosene space heaters. A well-tuned radiant heater and a maltuned convective heater were used for the study. Each heater was operated in a 27-cu m chamber with a prescribed on/off pattern. Organic compounds were collected on teflon-impregnated glass filters backed by XAD-2 resin and analyzed by gas chromatography/mass spectrometry. Pollutant source strengths were calculated using a mass-balance equation. The results show that kerosene heaters can emit polycyclic aromatic hydrocarbons (PAHs), nitrated PAHs; alkyl benzenes; pentachlorophenol; phtalates; hydro naphthalenes; aliphatic hydrocarbons, alcohols, and ketones; and other organic compounds.

5/7/18 (Item 18 from file: 103)
1222834 ERA-11:054789, EDB-86:177417 TIC Accession No.: DE86015133
Comparison of pollutant emission rates from unvented kerosene and gas space heaters
Apte, M.G.; Traynor, G.W.
Lawrence Berkeley Lab., CA (USA)
Managing indoor air for health and energy conservation Atlanta, GA, USA 20 Apr 1986
May 1986. 27 p.
Report No.: LBL-21571; CONF-860446-1
Contract No.: AC03-76SF00098
Journal Announcement: NTS8610
Availability: NTIS, PC A03/MF A01.
Document Type: Report; Conference literature
Language: English
Subfile: NTS (NTIS); ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

In this paper the pollutant emission rates of all five types of unvented space heaters are compared. Pollutant emission rates for carbon dioxide, carbon monoxide (CO), nitric oxide, nitrogen dioxide (NO2), formaldehyde, and submicron suspended particles were measured. Special emphasis is placed on CO and NO2 emissions. Pollutant measurements were made in a 27-mT environmental chamber and emission rates were calculated using a mass-balance model. Emission rates for propane and natural gas space heaters were similar. Emissions from the various types of heaters fall into three distinct groups. The groups are better characterized by burner design than by the type of fuel used. Radiant kerosene heaters and infrared UVGSHs constitute one group; convective kerosene heaters and convective UVGSHs the second, and two-stage kerosene heaters the third group. When groups are compared, emission rates vary by an order of magnitude for carbon monoxide and for nitrogen dioxide. The two-stage kerosene heaters emitted the least CO and also the least NO2 per unit of fuel energy consumed. The radiant/infrared heaters emitted the most CO, and the convective heaters emitted the most NO2. The effects of various operation parameters such as the wick height for kerosene heaters and the air shutter adjustment for gas heaters are discussed. Convective UVGSHs operating at half input were found to have lower emission rates on average than when operating at full input. Some maltuned convective UVGSHs were capable of emitting very high amounts of CO. Kerosene heaters were found to emit more CO and NO2 on average when they were operated with lowered wicks.

5/7/19 (Item 19 from file: 103)
1183474 NOV-85:015644, EDB-86:138057
Indoor air quality research related to unvented space convective heaters
Billick, I.H.
Environment and Safety Research, Gas Research Inst., Chicago, IL
American Society of Heating, Refrigerating and Air-Conditioning Engineers' semiannual meeting Honolulu, HI, USA 23 Jun 1985
ASHRAE Trans. (United States) v 91:2B. 1985. 251-260 p.
Coden: ASHTA
Report No.: CONF-850606-
Journal Announcement: EDB8608
Document Type: Journal Article; Conference literature
Language: English
Work Location: United States

Unvented hydrocarbon-fueled space heaters represent an alternative source of heating comfort for the consumer. Included in this category are kerosene, natural gas, and LPG-fueled convective heaters. The increased use of these heaters has drawn concern from some sources as presenting a potential health hazard as a result of decreased indoor air quality from the unvented

combustion products. The U.S. Consumer Product Safety Commission (CPSC), in particular, has instituted a major program to bring about the adoption of voluntary standards for the emission rates of trace gases from unvented space heaters. Both the kerosene heater industry and the gas industry have established technical task groups to work with the CPSC to identify and resolve the technical issues associated with the need for an emission standard from unvented heaters. All three groups are supporting research to support these task groups. The research currently underway addresses problems associated with emission measurement protocols, emission product concentration distribution under controlled test house conditions, heater use studies, and field surveys of emission product levels. The gas industry's research projects are described and preliminary results from some of them presented.

5/7/20 (Item 20 from file: 103)
1159329 ERA-11:037311, EDB-86:113912 TIC Accession No.: DE86011553
Selected organic pollutant emissions from unvented kerosene heaters
Traynor, G.W.; Apte, M.G.; Sokol, H.A.; Chuang, J.C.; Mumford, J.L.
Lawrence Berkeley Lab., CA (USA); Battelle Columbus Labs., OH (USA). Analytical and Structural Chemistry Center; Environmental Protection Agency, Research Triangle Park, NC (USA). Health Effects Research Lab.
Air Pollution Control Association annual meeting and exhibition Minneapolis, MN, USA 22 Jun 1986
Mar 1986. 22 p.
Report No.: LBL-21355; CONF-860606-8
Contract No.: AC03-76SF00098
Journal Announcement: NTS8607
Availability: NTIS, PC A02/MF A01.
Document Type: Report; Conference literature
Language: English
Subfile: NTS (NTIS); ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

This study has confirmed the results of other studies, i.e., that the kerosene combustion process can emit PAHs and nitrated-PAHs. In addition, kerosene heaters were found to emit many other organic compounds, including aliphatic hydrocarbons, alcohols, and ketones; phthalates; alkyl benzenes; and pentachlorophenol. Additional analysis is needed to correlate these results with health-effects data to determine the risk associated with these organic emissions. PAH and nitrated-PAH emissions are sufficiently important to justify additional quantitative studies; furthermore, examinations of other organic compounds of toxicological significance and of unvented combustion sources should be expanded. One very important observation of this study was that some estimates of the indoor reactivity of SVOCs were higher than 2 h . This implies that reactivity rates for some SVOCs are more important than ventilation rates for determining indoor concentrations. Clearly, this indicates that future studies must quantify the indoor reactivity process for indivisual SVOCs in order to gain insight into potential indoor exposures to these compounds.

5/7/21 (Item 21 from file: 103)
1138596 EDB-86:093179
Results of testing unvented kerosene heaters in a house: gas emissions, surface temperatures and fuel consumption rates
Clarkson, S.G.; Tom, B.L.; Babcock, A.J.; Mehkeri, K.A.
Consumer and Corp. Affairs Canada, Ottawa, Ontario
Air Pollution Control Association annual meeting San Francisco, CA, USA 25 Jun 1984
Proc., Annu. Meet., Air Pollut. Control Assoc. (United States) v 2. 1984. 34 p.
Coden: PRAPA
Report No.: CONF-840612-
Journal Announcement: EDB8604

Document Type: Journal Article; Conference literature; Numerical data
Language: English
Work Location: Canada

In response to concerns about the safety of unvented kerosene heaters, Consumer and Corporate Affairs Canada (CCAC) funded the Consumers' Association of Canada (CAC) to carry out a study under the guidance of Scientific and Laboratory Services Division of CCAC to investigate kerosene heater performance in areas such as stability, surface temperatures and emission levels of combustion products. The CAC study monitored the levels of carbon monoxide, carbon dioxide and oxides of nitrogen (NO/sub x/) emitted by twelve heaters in a controlled environment chamber. A few additional tests were carried out in a home located in Greely, Ontario with two of these heaters. The levels of the combustion gases were found to be markedly lower than those measured during chamber tests. A second in-house study was initiated by CCAC to expand upon the house tests done by CAC. During this study more unvented kerosene heaters were tested and gas concentrations were measured in rooms remote from the one in which the heater was located. Four radiant and four convective type kerosene heaters were tested including the two previously studied in the home in greely as well as two others from the CAC study.

5/7/22 (Item 22 from file: 103)
1122443 EDB-86:077024
Comparative study of combustion in kerosene heaters
Lionel, T.; Martin, R.J.; Brown, N.J.
Lawrence Berkeley Lab., CA
Environ. Sci. Technol. (United States) v 20:1. Jan 1986. 78-85 p.
Coden: ESTHA
Contract No.: AC03-76SF00098
Journal Announcement: ERA8605
Document Type: Journal Article
Language: English
Subfile: ERA (Energy Research Abstracts)
Work Location: United States

The combustion characteristics of radiant, convective, and multistage kerosene heaters have been determined and compared. Two types of experiments were conducted. In the first of these, composition and temperature were measured as a function of axial position in the heater to determine the progress of combustion. In the second type, composition, fuel consumption rate, temperature, pressure, and exhaust stream mass flow rate were measured in an exhaust manifold to ascertain the effect of heater type and heater operating conditions on exhaust gas composition. Fuel consumption was sensitive to wick height, wick age, and volume of fuel in the tank. Heater design strongly influenced emission rates. The convective and multistage heaters produced the smallest amounts of CO (per kilojoule). The radiant heater produced the largest amounts of CO and the smallest amounts of NO/sub x/. The convective heater produced the largest amounts of NO/sub x/. Results were compared with chamber and other laboratory studies, and agreement among the various studies was found to be quite satisfactory. 12 references, 4 figures, 8 tables.

5/7/23 (Item 23 from file: 103)
1085241 NET-84:60782, EDB-86:039821
Emissions from unvented kerosene heaters
Ragland, K.W.; Andren, A.W.; Manchester, J.B.
Wisconsin-Madison Univ. (USA)
Sci. Total Environ. (Netherlands) v 46:1. Nov 1985. 171-179 p.
Coden: STEVA
Journal Announcement: EDB8602
Document Type: Journal Article
Language: English

Work Location: United States

Vapor-phase polynuclear aromatic hydrocarbon (PAH) emissions from unvented kerosene heaters were measured. During normal heater operations, tri- and tetra-cyclic PAHs were observed, whereas penta-, hexa- and hepta-cyclic PAHs were not observed. The convective-type heaters had significantly less PAH emissions than the radiant-type heaters. Emissions of particulate soot were also measured. The soot did not contain PAH. A two-compartment model is presented and used to simulate heater operation in a home. Certain simulated PAH levels are similar to that measured in the ambient air of large cities. (A.V.)

5/7/24 (Item 24 from file: 103)
1069974 EDB-86:024553
Kerosene controversy
McClintock, M.
Rodale's New Shelter (United States) v 6:8. Oct 1985. 30-33 p.
Coden: RNSHD
Journal Announcement: EDB8602
Document Type: Journal Article
Language: English
Work Location: United States

Controversy over warnings about the safety of kerosene space heaters, which were felt by many to have unacceptable fire and air pollution risks, has led to improved models. New kerosene heaters have birdcage grilles to prevent burns and tipover shut-off switches to prevent fires. They are available in portable and console models. Indoor pollution tests which found significantly higher levels of carbon monoxide, nitrogen oxide, and particulates in monitored houses also found that the threshold for emission problems is 85/sup 0/F. The Consumer Product Safety Commission recommends that even the new models be operated with open doors. Unvented gas heaters introduce the same hazards, while asbestos, formaldehyde, and other substances also represent health hazards. The author provides guidelines for buying and operating a kerosene heater.

5/7/25 (Item 25 from file: 103)
1030211 EDB-85:167903
Mutagenic/carcinogenic agents in indoor pollutants; the dinitropyrenes generated by kerosene heaters and fuel gas and liquefied petroleum gas burners
Tokiwa, H.; Nakagawa, R.; Horikawa, K.
Fukuoka Environmental Research Center, Japan
Mutat. Res. (Netherlands) v 1. Jul 1985. 39-47 p.
Coden: MUREA
Journal Announcement: EDB8509
Document Type: Journal Article
Language: English
Work Location: Japan

Incomplete combustion of kerosene heater, and fuel gas and liquefied petroleum gas-burner emissions produces indoor pollutants that may be carcinogenic. The incomplete-combustion products from each type of appliance were therefore collected by adsorption on about 3 g of XAD-2 resin, and were extracted with benzene-methanol as a solvent for determination and identification of mutagens in the Salmonella-microsome test system. Benzene-methanol extracts of the particulates generated by a heater and two burners showed extreme mutagenicity for strains TA97 and TA98 without S9 mix. Based on the results of analysis, a combination of high performance liquid chromatography (h.p.l.c.) and gas chromatography (GC), about 40-80% of the direct-acting mutagenicity in each crude extract showed the same h.p.l.c. and GC retention times as dinitropyrenes (1,3-, 1,6- and 1,8-isomers), and 1-nitropyrene. Moreover, other nitroarenes, 2-nitrofluorene, 1,5- and 1,8-dinitronaphthalene, and 4,4'-dinitrobiphenyl, were detectable in almost all samples, but their contribution to the mutagenicity of each extract was very low. Kerosene heaters were found to generate small amounts (0.2 ng/h) of dinitropyrenes, which are potential mutagens/carcinogens, only after 1 h of operation.

5/7/26 (Item 26 from file: 103)
406211 EDB-85:012934
Device for collecting emissions from kerosene heaters
Gilloti, N.J.
Patent No.: US 4,469,084 Assignees: Spinair Corp.
Filed date 27 May 1983
4 Sep 1984. v p.
Journal Announcement: EDB8412
Note: PAT-APPL-499116
Document Type: Patent
Language: English
Country of Publication: United States
Work Location: United States

An apparatus for both improving the heat distribution throughout a room from a portable kerosene heater and for collecting undesirable emissions resulting from the burning of the kerosene, includes a base adapted to be mounted on the top of the heater, the base supporting a vertically extending shaft on which is mounted a heat-driven fan formed of either paper or metal, and a disposable disk mounted a spaced distance above the fan on the same shaft, the disk serving as a collector for the undesirable emissions. When the device is placed on an operating kerosene heater, the rising hot air and gases from the heater cause the fan to rotate, which in turn causes emissions from the burning fuel to move upwardly in a more or less cylindrical path. As the products of combustion move upwardly, certain emissions therein such as soot, oily vapors, etc. deposit or condense onto the surface of the spinner and disposable disk.

5/7/27 (Item 27 from file: 103)
392094 EDB-84:189870 TIC Accession No.: DE85000673
Comparative study of combustion in unvented space heating devices
Lionel, T.; Martin, R.J.; Brown, N.J.
Lawrence Berkeley Lab., CA (USA)
Fall meeting of the Western States Section of the Combustion Institute Stanford, CA, USA 22 Oct 1984
Oct 1984. 42 p.
Report No.: LBL-18535; CONF-8410156-4
Contract No.: AC03-76SF00098
Journal Announcement: ERA8411
Availability: NTIS, PC A03/MF A01; 1.
Note: Portions are illegible in microfiche products
Document Type: Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts); NTS (NTIS)
Country of Publication: United States
Work Location: United States

The combustion characteristics of radiant, convective, and multi-stage kerosene heaters have been determined and compared. Two types of experiments were conducted. In the first of these, composition and temperature were measured as a function of axial position in the heater to determine the progress of combustion. In the second type, composition, fuel consumption rate, temperature, pressure, and exhaust stream mass flow rate were measured in an exhaust manifold to ascertain the effect of heater type and heater operating conditions on exhaust gas composition. Fuel consumption was sensitive to wick height, wick age, and volume of fuel in the tank. Heater design strongly influenced emission concentrations. The multi-stage heater had the strongly influenced emission concentrations. The multi-stage heater had the smallest concentration of CO and intermediate concentrations of NO/sub x/. The radiant heater had the largest concentrations of CO and smallest NO/sub x/ concentrations. The convective heater had the

greatest NO/sub x/ concentrations. Results were compared with chamber and other laboratory studies, and agreement among the various studies was found to be quite satisfactory.

5/7/28 (Item 28 from file: 103)
298146 EDB-84:095909
Effect of kerosene heater emissions on indoor air quality and pulmonary function
Cooper, K.R.; Alberti, R.R.
Department of Medicine, Virginia Commonwealth University-Medical College of Virginia, Richmond
Am. Rev. Respir. Dis. (United States) v 129:4. Apr 1984. 629-631 p.
Coden: ARRDA
Journal Announcement: EDB8406
Document Type: Journal Article
Language: English
Work Location: United States

We monitored sulfur dioxide (SO/sub 2/) and carbon monoxide (CO) concentrations in 14 suburban homes while modern kerosene heaters were operating. Mean concentrations were 7 parts per million (PPM) CO and 0.4 PPM SO/sub 2/. Carboxyhemoglobin levels were significantly increased (p less than 0.0001), but performance on spirometric tests was not worsened by exposure to heater emissions in the 29 healthy residents of these homes. Our monitoring data agrees closely with predictions based on computer modeling and data from an environmental chamber study. Although we found no definite hazard for normal individuals, the concentration of either SO/sub 2/ or CO exceeded standards for outdoor air quality in 8 of the 14 homes. Moreover, the SO/sub 2/ concentrations we measured are sufficient to induce bronchospasm in some asthmatics. People with asthma should be informed of this risk.

5/7/29 (Item 29 from file: 103)
289392 ERA-09:027199, EDB-84:087154 TIC Accession No.: TI83004093
Pollutant emission rates from indoor combustion appliances and sidestream cigarette smoke

Energy and Environment Division, annual report, FY 1981
Girman, J.R.; Allen, J.R.; Apte, M.G.; Hollowell, C.D.; Martin, V.M.; Traynor, G.W.
Lawrence Berkeley Lab., CA (USA)
Sep 1982. 3.15-3.17 p.
Report No.: LBL-13500
Contract No.: AC03-76SF00098
Journal Announcement: EDB8405
Availability: NTIS, PC A15/MF A01; 1.
Document Type: Analytic of a Report; Numerical data
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

Calculating emission rates of these combustion-generated pollutants is an essential step in assessing the degree to which these pollutant sources affect indoor air quality. In this paper, we report the pollutant emission rates derived from our studies of a gas-fired stove, gas-fired unvented space heater, kerosene-fired unvented space heater, and sidestream cigarette smoke. These experiments were carried out in an environmental chamber under controlled ventilation, and our Mobile Atmospheric Research Laboratory was used to measure gas-phase pollutant concentrations.

5/7/30 (Item 30 from file: 103)
287968 ERA-09:026949, EDB-84:085730 TIC Accession No.: TI84004447
Pollutant emissions rates from indoor combustion appliances and sidestream cigarette smoke

International symposium on indoor air pollution, health and energy conservation. EXtended summaries
Girman, J.R.; Apte, M.G.; Traynor, G.W.; Hollowell, C.D.
Lawrence Berkeley Lab., CA
International symposium on indoor air pollution, health and energy conservation Amherst, MA, USA 13 Oct 1981
1981. 4p, Paper 44 p.
Report No.: CONF-811048-Summs.
Contract No.: W-7405-ENG-48
Journal Announcement: EDB8406
Availability: NTIS, PC A23/MF A01; 1.
Document Type: Analytic of a Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

Gas-fired stoves and unvented space heaters (both kerosene- and natural gas-fired types) emit such potentially harmful pollutants as carbon monoxide (CO), carbon dioxide (CO/sub 2/), nitric oxide (NO), nitrogen dioxide (NO/sub 2/), sulfur dioxide (SO/sub 2/), formaldehyde (HCHO) and respirable particulates; sidestream tobacco smoking emits CO, CO/sub 2/, NO, NO/sub 2/, respirable particulates and a wide range of organic compounds. The degree of the indoor air pollution depends on the type and amount of pollutants entering the occupied space and the type and rate of removal processes occurring. In this paper, we report the pollutant emission rates derived from our studies of a gas-fired stove, gas-fired unvented space heater, kerosene-fired unvented space heater and sidestream cigarette smoke. (DT)

5/7/31 (Item 31 from file: 103)
233483 EDB-84:031123
Residential air pollution from kerosene heaters
Ritchie, I.M.; Oatman, L.A.
Indiana Univ., Bloomington
J. Air Pollut. Control Assoc. (United States) v 33:9. Sep 1983. 879-881 p.
Coden: JPCAA
Journal Announcement: EDB8402
Document Type: Journal Article
Language: English
Work Location: United States

The studies provide data on pollution emissions from kerosene heaters operated under laboratory conditions for short time periods. The need for data on pollutant levels resulting from the residental use of unvented kerosene heaters prompted the investigation. Air contaminant levels were greater than recommended guidelines and therefore could be presumed to pose a health risk to susceptible individuals. (1 table)(DP)

5/7/32 (Item 32 from file: 103)
219593 EDB-84:017231
Indoor house pollution: appliance emissions and indoor ambient concentrations
Caceres, T. (Univ. of Santiago, Chile); Soto, H.; Lissi, E.; Cisternas, R.
Atmos. Environ. (United Kingdom) v 17:5. 1983. 1009-1013 p.
Coden: ATENB
Journal Announcement: EDB8401
Document Type: Journal Article
Language: English
Work Location: Chile

Emissions rates for CO, NO, NO/sub 2/ adn CH/sub 2/O from several unvented gas and

kerosene heaters frequently employed in domestic heating have been measured. The indoor concentrations generated by these emissions are evaluated and compared to those determined in typical houses. It is found that both the predicted and measured values exceed the short term air quality standards accepted in most countries.

5/7/33 (Item 33 from file: 103)
219579 EDB-84:017217
The effects of kerosene heaters on indoor pollutant concentrations: a monitoring and modeling study
Ryan, P.B.; Spengler, J.D.; Letz, R.
Harvard School of Public Health, Boston, MA
Atmos. Environ. (United Kingdom) v 17:7. 1983. 1339-1345 p.
Coden: ATENB
Journal Announcement: EDB8401
Document Type: Journal Article
Language: English
Work Location: United States

The increase in use of kerosene heaters as a supplementary heat source represents a possible new source of pollutant emissions in the indoor environment. By-products of kerosene combustion including NO/sub 2/ and SO/sub 2/ may be expected to be present in residences using these appliances. A two-phase study including both monitoring in the field and modeling was undertaken. Monitoring of NO/sub 2/ by passive diffusion samplers showed indoor concentrations ranging from 50 to 300 ..mu..g m/sup -3/ in buildings using these appliances and no other open combustion sources. Modeling of both NO/sub 2/ and SO/sub 2/ concentrations and exposures suggest the possibility of very high pollutant concentrations in poorly-ventilated or small-mixing volumes.

5/7/34 (Item 34 from file: 103)
125119 EDB-83:125132 TIC Accession No.: DE83014326
Measurements of emission factors of kerosene heaters
Woodring, J.L.; Duffy, T.L.; Davis, J.T.; Bechtold, R.R.
Argonne National Lab., IL (USA)
American industrial hygiene conference Philadelphia, PA, USA 22 May 1983
1983. 37 p.
Report No.: CONF-830584-2
Contract No.: W-31-109-ENG-38
Journal Announcement: ERA8307
Availability: NTIS, PC A03/MF A01; 1.
Note: Portions are illegible in microfiche products
Document Type: Report; Conference literature
Language: English
Subfile: ERA (Energy Research Abstracts); NTS (NTIS)
Country of Publication: United States
Work Location: United States

Emission factors were determined for both radiant and convective kerosene space heaters to determine ventilation standards for household use. Carbon monoxide, sulfur dioxide, nitrogen dioxide, formaldehyde, hydrocarbons, and particulates were determined for low sulfur and higher sulfur grade fuels. (PSB)

5/7/35 (Item 35 from file: 103)
078440 ERA-08:027390, EDB-83:078448 TIC Accession No.: DE83009140
Indoor air pollution from portable kerosene-fired space heaters (Effects of wick height and fuel consumption rate)
Traynor, G.W.; Apte, M.G.; Dillworth, J.F.; Grimsrud, D.T.

Lawrence Berkeley Lab., CA (USA)
Symposium on the health and safety of kerosene heaters Hempstead, NY, USA 8 Nov 1982 Feb 1983. 17 p.
Report No.: LBL-15612; CONF-821181-1
Contract No.: AC03-76SF00098
Journal Announcement: NTS8304
Availability: NTIS, PC A02/MF A01.
Document Type: Report; Conference literature
Language: English
Subfile: NTS (NTIS); ERA (Energy Research Abstracts)
Country of Publication: United States
Work Location: United States

Indoor use of unvented combustion appliances is known to cause an increase in indoor air pollutant levels. Laboratory tests were conducted on radiant and convective portable kerosene-fired space heaters to identify the pollutants they emit and to determine their emission rates. Laboratory-derived CO and NO/sub 2/ emission rates from unvented portable kerosense-fired space heaters are summarized and the effect of wick height and fuel consumption rate on CO and NO/sub 2/ emissions is given. Pollutant concentration profiles resulting from the use of kerosene heaters in a 27m/sup 3/ environmental chamber and a 240m/sup 3/ house are presented. When such heaters are operated for one hour in a 27m/sup 3/ chamber with 0.4 air changes per hour, the resultant CO/sub 2/ concentrations are well above the U.S. occupational standard, and NO/sub 2/ concentrations are well above California's short-term outdoor standard. Further data on parameters such as heater usage patterns and air exchange rates are needed to determine the actual pollutant exposure that kerosene heater users experience.

5/7/36 (Item 36 from file: 103)
069365 EDB-83:069372
Air-pollutant emissions from kerosene space heaters
Leaderer, B.P.
Yale Univ., New Haven, CT
Science (Washington, D.C.) (United States) v 218. 10 Dec 1982. 1113-1115 p.
Coden: SCIEA
Journal Announcement: EDB8304
Document Type: Journal Article; Numerical data
Language: English
Work Location: United States

Air pollutant emissions from portable convective and radiant kerosene space heaters were measured in an environmental chamber. Emission factors for nitrogen oxides, sulfur dioxide, carbon monoxide, carbon dioxide, and oxygen depletion are presented. The data suggest that the use of such heaters in residences can result in exposures to air pollutants in excess of ambient air quality standards and in some cases in excess of occupational health standards.

5/7/37 (Item 1 from file: 40)
0184782 Enviroline Number: *86-060671
A Comparative Study of Combustion in Kerosene Heaters,
Lionel Trudy; Martin Richard J.; Brown Nancy J.
LBNL,
ENV Science & Technology, JAN 86, V20, N1, P78(8)

Research Article the combustion characteristics of radiant, convestive, and multistage kerosene heather were determined and compared. Composition and temperature were measured as a function of axial position in the heater to assess the progress of combustion. Composition, fuel consumption rate, temperature, pressure, and exhaust stream mass flow rate were measured to ascertain the effect of heater type and operating conditions on emissions. Convective and

multistage heaters produced the smallest amounts of carbon monoxide. The radiant system produced the larger amounts of CO and the smallest amounts of nitrogen oxides. Fuel consumption was sensitive to wick height, wick age, and volume of fuel in the tank.

5/7/38 (Item 2 from file: 40)
0180669 Enviroline Number: *86-033051
The Kerosene Heater Controversy,
Energy Auditor & Retrofitter, JAN-FEB 85, V2, N1, P27(5)
Journal article kerosene heaters are an inexpensive, efficient means of providing residential space heat. State laws have restricted kerosene heater use to protect consumers from two dangers. These systems are potential fire hazards, and they cause indoor air pollution. Guidelines for enhancing the safety of kerosene heaters and for reducing pollutant emissions are summarized. (1 drawing, 3 references, 3 tables)

5/7/39 (Item 3 from file: 40)
0179188 Enviroline Number: *85-023042
Pollutant Emissions from Kerosene Heaters and Unvented Gas Space Heaters (Chemical Characterizaton & Personal Exposure)
PORTER WARREN K.
US Consumer Product Safety Commission, DC,
WHO/ET AL 3RD Intl. Indoor Air Quality & Climate Conf., Stockholm, AUG 20-24, 84, V4, P265(6)
Conf paper indoor air pollutant emissions were determined on 12 kerosene heaters operated at normal and low fuel consumption rates. Heaters with an open flame produced nitrogen dioxide and nitric oxide at rates greater than heaters with the flame enclosed in a perforated metal housing. Conversely, the carbon monoxide emission rate of blue-flame heaters was about five times the emission rates of white-flame heaters. (9 references, 3 tables)

5/7/40 (Item 4 from file: 40)
0175545 Enviroline Number: 85-003624
A Study of Particulate Emissions from Portable Space Heaters,
Tu K. W.; Hinchliffe L. E.
DOE, NY,
American Industrial Hygiene ASSN J, NOV 83, V44, N11, P857(6) Research Article
Particulate emissions from five portable residential space heaters were measured in a 31 CU/M room with a ventilation rate of three air changes per hour. Measurements were also made in an 11 CU/M air-tight chamber. The heaters tested each had different heating mechanisms and were fueled by either electricity or kerosene. Conventional electrical heaters produced ultrafine particles, while the quartz and kerosene devices released larger particles up to 3 mm in diameter. The particle number and mass concentrations were in the ranges of 104 - 106 particles/CU/M and 1-300 MG/CU/M respectively. The kerosene heater released one to two orders of magnitude more particles than the other units. (3 graphs, 2 photos, 15 references, 2 tables)

5/7/41 (Item 5 from file: 40)
0164053 Enviroline Number: *83-002833
Air Pollutatn Emissions from Kerosene Space Heaters,
Leaderer, Brian P.
Yale Univ,
Science, DEC 10, 82, V218, N4577, P1113 (3)
Technical feature air pollutant emissions from portable convective and radiant kerosene space heaters were measured. Emission factors for nitrogen oxides, sulfur dioxide, carbon monoxide, carbon dioxide, and oxygen depletion are examined. The use of such heaters in residences can result in exposures to pollutants in excess of ambient air quality standards. (2 graphs, 7 references, 1 table)

5/7/42 (Item 6 from file: 40)
0124245 Enviroline Number: 77-006235
Reduction of Carbon Monoxide from Domestic Kerosene Heaters,
Rashidi, M.; Massoudi M. S.; Shadman F.
Arya-Mehr Univ OF Technology, Iran,
J Enf Science & Health-Env Science & Engineering, 1977, V12, N3, P115 (12)
Research Report. An experiment was conducted to develop methods or devices for reducing carbon monoxide concentrations caused by kerosene heaters. A device applying the idea of both thermal reactor and catalysis was developed. This proved very effective in oxidizing CO and unburnt hydrocarbons emitted by a wick-type kerosene heater. The reduction in CO level was achieved by obtaining uniform misture distribution of the products, and by allowing longer reaction time for complete combustion and slower cooling of the products. Using the device, reduction of CO to one-sixth of the normal concentration was achieved. However, nitorgen oxides in the combustion products increased by about 10%. Use of reducing or oxidizing catalytic agents in addition to the device did not prove effective in further reducing the undesirable emissions. (2 diagrams, 3 graphs, 7 references)

5/7/43 (Item 1 from file: 41)
88-03004
Characterization of particle composition, organic vapor constituents, and mutagenicity of indoor air pollutant emissions
Berglund, B.; Berglund, U.; Lindvall, T.; Spengler, J.; Sundell, J. (eds.); Sexton, K.; Webber, L.M.; Hayward, S.B.; Sextro, R.G.
Health Effects Inst., 215 First St., Cambridge, MA 02142, USA
3. International Conference on Indoor Air Quality and Climate Stockholm (Sweden) 1984
ENVIRON. INT VOL. 12, NO. 1-4, pp. 351-362, Publ.Yr: 1986
SUMMARY LANGUAGE - ENGLISH; Special issue: Indoor air quality.
Languages: ENGLISH
Journal Announcement: V19N3
A joint chamber experiment was carried out by the California Indoor Air Quality Program and Lawrence Berkeley Laboratory to characterize particle and organic vapor emissions from several important indoor sources, including a gas range, tobacco smoking, hamburger frying, a kerosene heater, and selected aerosol spray products. Among the emissions data collected for each source were particle size distributions, particle-phase chemical compositions, volatile organic compounds, and mutagenicity of particles and vapor-phase constituents. Findings were used to assess qualitatively the nature of airborne emissions from each source and to compare emission constituents among source categories. This approach is a necessary first step in evaluating the feasibility of developing unique signatures for individual sources using a broad array of emission characteristics.

5/7/44 (Item 2 from file: 41)
88-01069
The nature of the mutagenicity and carcinogenicity of nitrated, aromatic compounds in the environment
Tokiwa, H.; Nakagawa, R.; Horikawa, K.; Ohkubo, A.
Bacteriol. and Epidemiol. Div., Fukuoka Environ. Res. Cent., Fukuoka 818-01, Japan
ENVIRON. HEALTH PERSPECT VOL. 73, pp. 191-199, Publ.Yr: 1987
SUMMARY LANGUAGE - ENGLISH; Special section: Experimental studies on health effects of nitrogen oxides.
Languages: ENGLISH
Journal Announcement: V19N1
Gaseous substances such as nitrogen dioxide (NO sub(2)) and sulfur dioxide (SO sub(2)) stimulate the process of nitration of polycyclic aromatic hydrocarbons, and the transformation

products display a broad spectrum of mutagenicity, genotoxicity, and carcinogenicity. Bacterial mutation by nitroarenes is specific. Tetracyclic nitroarenes are thought to be the most mutagenic compounds in the Salmonella test system, and some are carcinogenic in rats and mice. Furthermore, it was found that the mutational nitroarenes produced mostly DNA damage, which is subject to recombination repair in the rec assay system using Bacillus subtilis). Nitroarenes in the environment seem to be ubiquitous; the majority of the compounds are emitted directly from diesel emissions, kerosene heater, and gas and liquefied-gas burners or heaters. In nitroarenes induced during incomplete combustion, nitropyrene and nitrofluoranthene derivatives are the most important mutagens/carcinogens for determining the chronic toxicity of nitroarenes overall.

5/7/45 (Item 3 from file: 41)
87-04714
Emission rates from range-top burners -- assessment of measurement methods
Moschandreas, D.J.; Relwani, S.M.; Billick, I.H.; Macriss, R.A.
IIT Res. Inst., 10 W. 35th St., Chicago, IL 60616, USA
Conference on Characterization of Contaminant Emissions from Indoor Sources Research Triangle Park, NC (USA) May 1985
ATMOS. ENVIRON VOL. 21, NO. 2, pp. 285-289, Publ.Yr: 1987
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

Unvented combustion sources in indoor environments generate emissions that contribute to indoor air pollution. Both the direct and mass-balance methods have been used to measure emission rates from these sources in field houses, test houses and chambers. In particular, emission rates have been obtained for pollutants from kerosene space heaters and from unvented gas appliances such as range-top burners, ovens, dryers and gas space heaters. Most studies have focused on the emission rates of the inorganic air constituents (NO, NO sub(2), CO and a few others). This paper compares the two methods of emission rate measurement, and summarizes the emission rates of NO, NO sub(2) and CO from range-top burners.

5/7/46 (Item 4 from file: 41)
87-02802
Mutagenic/carcinogenic agents in indoor pollutants; the dinitropyrenes generated by kerosene heaters and fuel gas and liquefied petroleum gas burners
Tokiwa, H.; Nakagawa, R.; Horikawa, K.
Epidemiol. and Bacteriol. Div., Fukuoka Environ. Res. Cent., Fukuoka 818-1, Japan
MUTAT. RES VOL. 157, NO. 1, pp. 39-47, Publ.Yr: 1985
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

Incomplete combustion of kerosene heater, and fuel gas and liquefied petroleum gas-burner emissions produces indoor pollutants that may be carcinogenic. The incomplete-combustion products from each type of appliance were therefore collected by adsorption on about 3 g of XAD-2 resin, and were extracted with benzene-methanol as a solvent for determination and identification of mutagens in the Salmonella -microsome test system. Benzene-methanol extracts of the particulates generated by a heater and two burners showed extreme mutagenicity for strains TA97 and TA98 without S9 mix. Based on the results of analysis, a combination of high performance liquid chromatography (h.p.l.c.) and gas chromatography (GC), about 40-80% of the direct-acting mutagenicity in each crude extract showed the same h.p.l.c. and GC retention times as dinitropyrenes (1.3-, 1,6- and 1,8-isomers), and 1-nitropyrene. Kerosene heaters were found to generate small amounts (0.2 ng/h) of dinitropyrenes, which are potential mutagens/carcinogens only after 1 h of operation.

5/7/47 (Item 5 from file: 41)
87-01532
Selected organic pollutant emissions from unvented kerosene heaters
Traynor, G.W.; Apte, M.G.; Sokol, H.A.; Chuang, J.C.; Mumford, J.L.

Univ. California, Lawrence Berkeley Lab., Berkeley, CA 94720, USA
Publ.Yr: 1986
NTIS, SPRINGFIELD, VA (USA)
SUMMARY LANGUAGE - ENGLISH; PB86-218443/GAR.
Languages: ENGLISH

An exploratory study was performed to assess the semivolatile and nonvolatile organic-compound emissions from unvented kerosene space heaters. A well-tuned radiant heater and a maltuned convective heater were used for the study. Each heater was operated in a 27-cu m chamber with prescribed on/off pattern. Organic compounds were collected on teflon-impregnated glass filters backed by XAD-2 resin and analyzed by gas chromatography/mass spectrometry. Pollutant source strengths were calculated using a mass-balance equation. The results show that kerosene heaters can emit polycyclic aromatic hydrocarbons (PAHs), nitrated PAHs; alkyl benzenes; pentachlorophenol; phtalates; hydro naphthalenes; aliphatic hydrocarbons, alcohols, and ketones; and other organic compounds.

5/7/48 (Item 6 from file: 41)
86-08792
Measurements of combustion product emission factors of unvented kerosene heaters
Woodring, J.L.; Duffy, T.L.; Davis, J.T.; Bechtold, R.R.
Argonne Natl. Lab., Occup. Health and Saf. Dep., Argonne, IL 60439, USA
AM. IND. HYG. ASSOC. J VOL. 46, NO. 7, pp. 350-356, Publ.Yr: 1986
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

Emissions of combustion products from unvented kerosene heaters were measured in an exhaust system used to ventilate the units. Measurements of carbon monoxide, nitrogen dioxide, sulfur dioxide, formaldehyde and particulates are reported and compared with the results of several other studies. Dilution ventilation requirements to maintain occupational and air quality standards are presented.

5/7/49 (Item 7 from file: 41)
86-01503
A comparative study of combustion in kerosene heaters
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ENVIRON. SCI. TECHNOL VOL. 20, NO. 1, pp. 78-85, Publ.Yr: 1986
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

The combustion characteristics of radiant, convective, and multistage kerosene heaters have been determined and compared. Two types of experiments were conducted, In the first of these, composition and temperature were measured as a function of axial position in the heater to determine the progress of combustion. In the second type, composition, fuel cosumption rate, temperature, pressure, and exhaust stream mass flow rate were measured in an exhaust manifold to ascertain the effect of heater type and heater operating conditions on exhaust gas composition. Fuel consumption was sensitive to wick height, wick age, and volume of fuel in the tank. Heater design strongly influenced emission rates.

5/7/50 (Item 8 from file: 41)
85-08773
Mutagenic/carcinogenic agents in indoor pollutants; the dinitropyrenes generated by kerosene heaters and fuel gas and liquefied petroleum gas burners
Tokiwa, H.; Nakagawa, R.; Horikawa, K.
Epidemiol. and Bacteriol. Div., Fukuoka Environ. Res. Cent., Fukuoka 818-01, Japan
MUTAT. RES VOL. 157, pp. 39-47, Publ.Yr: 1985 SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

Incomplete combusion of kerosene heater, and fuel gas and liquefied petroleum gas-burner emissions produces indoor pollutants that may be carcinogenic. The incomplete-combustion products from each type of appliance were therefore collected by adsorption on about 3 g of XAD-2 resin, and were extracted with benzene-methanol as a solvent for determination and identification of mutagens in the Salmonella -microsome test system.Benzene-methanol extracts of the particulates generated by a heater and two burners showed extreme mutagenicity for strains TA97 and TA98 without S9 mix. Based on the results of analysis, a combination of high performance liquid chromatography (h.p.l.c) and gas chromatography (GC), about 40-80% of the direct-acting mutagenicity in each crude extract showed the same h.p.l.c. and GC retention times as dinitropyrenes (1,3- 1,6- and 1,8-isomers), and 1-nitropyrene. Moreover, other nitroarenes, 2-nitrofluorene, 1,5- and 1,8-dinitronaphthalene, and 4,4'-dinitrobiphenyl, were detectable in amost all samples, but their contribution to the mutagenicity of each extract was very low.

5/7/51 (Item 9 from file: 41)
84-03276
Residential air pollution for kerosene heaters
Ritchie, I.M.; Oatman, L.A.
Sch. Public Environ. Aff., Univ. Indiana, Bloomington, IN, USA
J. AIR POLLUT. CONTROL ASSOC VOL. 33, NO. 9, pp. 879-880, Publ.Yr: 1983
SUMMARY LANGUAGE - ENGLISH
Languages: ENGLISH

These studies provide data on pollutant emissions from kerosene heaters operated under laboratory conditions for short periods. The need for data on pollutant levels resulting from the residential use of unvented kerosene heaters prompted the following investigation.

5/7/52 (Item 10 from file: 41)
81-01513
Nitrogen oxides emissions from domestic kerosene-fired and gas-fired appliances.
Yamanaka, S.; Hirose, H.
Kyoto City Inst. of Public Health, Kyoto, Japan
Japan Air Cleaning Association. Journal 17(5), 2-6, Publ.Yr: Jan 1980 Coden: KUSEBF
illus. 2 refs.
Eng., Japanese abs.
Languages: Japanese
Doc Type: JOURNAL PAPER
TREATMENT CODES: G (GENERAL OR REVIEW)

Nitrogen oxide emission rates from appliances for heating, cooking, hot water, and bath furnaces were measured. Kerosene-fired heaters were classified into 2 groups-radiant and convection type. The blue flame of the latter resulted in NOx emission rates several times that of the former, a radiant IR type which had a metal screen in the flame. Gas-fired appliances were classified into the following 3 groups from the standpoint of NOx emission characteristics: bath furnace, hot water supplier, and gas burner using town gas (1), bath furnace and gas burner using liquefied petroleum gas (2), and gas stove using town gas or liquefied petroleum gas (3). Either group 1 or 2 shows a rather large, blue flame while fuel types are different. In contrast, group 3, a radiant IR type, shows a very fine, red flame on the porous ceramic plate and has an extremely low emission rate regardless of its fuel type. The NOx emission factor (NO2cm3/hr) for each group is presented.